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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVII, No. 7 OCTOBER, 1917 WHOLE No. 144

THE PHYSICAL SCIENCES IN HIGH SCHOOL AND COLLEGE.

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It is quite unnecessary for me to state at the outset that I shall not be able to touch upon more than a few of the problems which we encounter in teaching the physical sciences; as a matter of fact, I shall be more than satisfied if I can make even a slight impression upon two salients, the science of the junior high school and that of the junior college, as these are to be differentiated from high school science in general. It is almost as unnecessary, yet not quite, perhaps, for me to point out that while our progress to the present status of science teaching has been marked by some measure of success, it has also been marred by several notable failures. I need mention only the failure of nature study in the grades, the decline of physiography and of zoology in the high school, to say nothing of the small, almost vanishing, classes in some of the college sciences, such as geology, astronomy, and sometimes even physics. How much even we teachers of reasonably successful high school science feel the need of new names, if not of new methods, is abundantly evident when we call our courses household physics, household chemistry, civic biology, industrial physics, agricultural physics, agricultural chemistry, and so on. Sometimes, to be sure, these names really designate new courses, but too often they signify only that the science has need of a more popular label. Some people have even been known to insist that the high school science of today has abandoned the mastery of ideas and has become only a description of household, industrial, and agricultural processes, given empirically, and using the panoply of real science to give them dignity and attention. But these persons may be set down as giving pure, theoretical science to attenuated classes and envious of their more popular contemporaries.

But the greatest evidence of the failure of high school science, as I see it, is the challenge that is now being flung out to the laboratory method of instruction. The question being asked of us is too often: "Are you justifying the laboratory method by your results?" The conviction of a generation ago, held by people who themselves had had no laboratory instruction, was that even in beginning science experimentation was worth while, because it would give everyone the opportunity of getting acquainted with nature at first hand. It is probably needless for me to call your attention to the fact that serious qualifications of this theory are in vogue today. As I have studied science teaching in high schools and colleges in these latter days, I have heard altogether too many teachers in both classes of institutions voice their belief that the benefits of laboratory work are greatly overrated, that somehow or other pupils work blindly to get results, that even to many instructors the notebook seems to be the principal object of the laboratory course. Most of us probably share this belief to a greater or less extent. Now, I wish to call your attention to the fact that this is the very antithesis of the belief expressed more or less forcibly by the teachers of a few decades ago, who believed that universal experimentation was the certain herald of the intellectual millennium. Is it possible that in this day of laboratory opportunity we do not know of the struggle by which laboratory privileges were gained, and that we expect that the laboratory method, having been once wound up like some hundred year clock, will continue to run of itself? Can the laboratory method justify itself to this generation, not because we find it a convenient staff to lean upon as we jog along in educational ruts, but because we can see in it the possibility of new applications and of greater and more vital service?

We shall hear more of the laboratory method by and by. For the present let us consider hastily the theory of our high school science course. No one can doubt that the high school course represents a compromise, and a rather unsatisfactory one, between the old academy or preparatory school course and the modern one of the people's college. The sciences shared in this compromise when entrance boards admitted them, grudgingly, into the list of admission subjects. But the science courses, like the other preparatory courses, would not remain where the entrance boards located them. Year by year, as science has become more and more necessary to the common life, the high

school courses in science have been drifting farther and farther away from the original college entrance requirement and nearer to a real or fancied adaptation to the needs of the community.

The original idea of college entrance requirements, such as those in Greek, Latin and mathematics, was that the college would build upon the special foundation laid in the high school. This idea was later applied to the sciences. Thus, just as the reading of Horace and Livy presupposed a study of Caesar, Cicero and Virgil, and as college algebra and trigonometry were built upon beginning algebra, geometry and arithmetic, so college chemistry, college physics, college botany, college physiography were to be built upon preparatory courses in these subjects. Hence the careful detail with which these subjects were worked out by the colleges, in elaborate syllabi, for the guidance of high school teachers. Not only the topics to be studied from the text, but the experiments to be performed in the laboratory and on the lecture table, were laid out with painstaking exactness. To be sure, a little leeway was allowed, so that when the entrance requirement was fulfilled the teacher or student might do some of the work in which he was really interested, but by the time the required work was completed the spirit, if not the time, for initiative had passed.

What has been the result of all this careful planning and supervision on the part of the colleges and universities? Have they been able to articulate their science courses with those of the high school? Have they built upon the courses of the high school? Here and there, perhaps, yes; generally, no. The testimony of college and university professors is almost unanimous to the effect that they find themselves unable to build upon the high school courses in science; that the instructor of chemistry, for example, begins, in his freshman lectures, as though the students had had no chemistry in high school. There are some apparent exceptions to this statement: I mean the higher institutions in which there is a separation of the students who have presented the subject for entrance from those who have not. I said that this exception is apparent, for even when the division is made, the testimony usually is that after six weeks one section is as far advanced as the other and that the separation of the sections might as well be abandoned thereafter. Surely, you must have heard some of the extremists among college men say that they believe it would be better for the high school student not to study at all a science he is afterwards to study in college or

university, on the ground that he must unlearn so many of the things taught him in the high school.

I heard an interesting illustration of the foregoing only a few weeks ago. A professor of psychology wanted to change the entrance requirement for his course so that biology would be a preferred entrance prerequisite for it. He did this under the blissful delusion (how complete a delusion it is some of us may not realize) that pupils studying biology in the first or second high school year carry over enough of this subject into the second or third college year so that a psychology course may safely be built upon it. My impression is that if a college teacher desires his pupils to know the biology required for psychology he will need to bring the biology course nearer, in point of time, to the year in which the psychology is taken. He will be fortunate indeed if a sophomore who has studied freshman biology in college is found retaining enough knowledge for the purpose in hand.

What is the conclusion of the matter? Is it not (and I am sure most college men will grant the truth of this statement) that teachers of high school science should feel themselves free to shape their courses according to the real needs of their students? Not to shape merely the topics of a subject but the curriculum itself, whether the college man, with his own special science to teach, sees the immediate need of it or not. High school authorities are under a singular misapprehension, very often, of what the college man of science really desires. The acquisitions he wishes his pupils to have as a result of high school work are not facts and formulas, for these will inevitably be conceived in an immature way and imperfectly applied, but power, enthusiasm, the habit of observation of common happenings, and a common-sense explanation of them. Against such there is no law.

The freedom of the public school authorities to work out their own salvation in their own way is illustrated abundantly in this conference. For I take it that we are assembled not for the "reorganization and extension of the high school," but to take recognition of and to adapt ourselves to an accomplished fact. The junior high school, arising out of the administrative necessity of providing adequate housing at minimum cost to the large numbers of students who throng the upper grades of the grammar school and the first year of the high school, is seen now to have psychologic and pedagogic reasons for its existence,

as well as those of a more utilitarian character. The question for us, as science teachers, to consider is not so much whether or not we favor junior high schools, but what we are going to do with the opportunity which the present existence and certain extension of such schools thrusts upon us. Are we going to allow this opportunity to go by default? Are the seventh and eighth grades to be restored to science, or is the establishment of the junior high school to be merely the occasion for the introduction of more language, ancient and modern, more English, more mathematics, more history? I have seen some of the elaborate plans which the classicists have made for taking possession of these grades; what science receives will depend largely upon the constructive suggestions of science teachers and upon the vigor with which they drive these suggestions home.

There are four major suggestions to be answered by us if the authorities decide that science is to have its fair share of opportunity in the junior high school: (1) What is our fair share of the student's time? (2) What kind of science shall we bring to the student? (3) What kind of a teacher is to teach junior high school science? (4) Shall credit be given for such work toward college entrance?

What is our fair share of the student's time? When we remember that science makes up so much of our modern life, that students in the grades get practically none of it, that so many students who graduate from the junior high school will never enter the senior high school, we ought certainly to give the student the opportunity to devote five hours a week during each of the junior high school years to the study of science.

What shall we say in reply to the second question regarding the kind of science this junior high school science is to be? There is no doubt in my mind that for the eighth and ninth grades it should be a general science rather than any special science. Probably the best name for it would be "introductory science." Junior high school science should give to the adolescent boy and girl the common sense of phenomena, of machines, of life, of health. Boys and girls have seen these phenomena since babyhood; they have about them a constantly increasing mass of contrivances and of inventions; living things appeal to them; they are constantly asked to observe natural laws; why should they not have at this, the impressionable and enthusiastic part of their life, a glimpse into the reasons for the laws, the ways of the inventions, and the explanation of the phenomena?

Consequently it happens that those who advocate introductory science are most interested in it, not as a preparation for college, but as a part of life. Yet I believe that as a preparation for college a general science is better than any special science completed at least three years before college entrance can possibly be. Introductory science does not need to defend itself even on the ground that it is an excellent forerunner for the special sciences that follow it, although the testimony of teachers who are competent to speak from experience is practically unanimous on this point. Introductory science serves its purpose best not as a prerequisite but as a vision, as it were from the center of a great sphere, of the world by which the child is surrounded. Because it is essentially a point of vantage, it should not be any special science. A special science has its own aims and content; it leads the young student too far along a single radius of the sphere of knowledge instead of giving him the view from the center; it also possesses a technique that calls for too much that is unprofitable to a child of twelve or thirteen. Thus it happens that the very qualities which make the special science valuable for the more mature student make it repellant and impossible in the case of the younger boy and girl.

What are the topics to be studied in a course in introductory science? The child's environment is full of phenomena due to gravity, inertia, centrifugal action, cohesion, capillary action, buoyancy, density and the like. He need not postpone altogether the study of these topics until he reaches the third or fourth year of the high school. Out of them he can early be taught the ideas of matter, force, and energy. The study of the air affords the opportunity for the fascinating topics of fire, oxidation, carbon dioxide, elements and compounds, and heat, as well as of air pressure and pumps. The polarity of magnets, the attraction and repulsion of statically charged bodies, the production and simpler properties of electric currents, the elementary study of light and color, the cause of sound, the behavior of acids and alkalies toward each other and toward indicators—these topics never fail to interest the child. If rightly presented, they will surely lead him to further investigation and study. In the consideration of these topics the true teacher does not ask or expect from the pupil any chemical formulas and equations, nor yet the generalizations of physics, but he does look for the growth, in the pupil, of an interest in common happenings, the stimulation to reasonably accurate observa-

tion, the arousing of a desire on the pupil's part to answer by simple experimentation some of the multitude of questions that will surely arise as the realities of the universe surge up against his consciousness.

The course in introductory science will not end here; the study of the topics suggested will not have gone far before it will have involved the home and the host of ways in which the home has profited by discovery and invention, together with the question of its further improvement; it will have involved the weather, which makes shelter needful and which shows how nature performs her miracles of air and water on a large scale. There will also need to be a study of the soil, of the rocks that were before the soil, of modern agriculture and what it means to the life of every one of us. Then the study of life itself, not in the detail of courses of botany and zoology, but for the purpose of stimulating interest in and observation and appreciation of the great world of plants and animals and a little familiarity with the main facts of their structure, their relations to one another, and their injuries or uses to man. Following this preliminary study of life there may be an outline course in physiology and hygiene. This course, even if short, will be in a measure comparative and of far more value than if it were taught as an isolated fragment of the high school course.

How may such a general science course be taught? We are not limited to any one method, but I would like to suggest as an ideal the laboratory method. Suppose that the teacher were to take his pupils into the laboratory at the beginning of the course, to show them something of its equipment and to ask what they would like to study. Suppose that the possible topics—possible because they come within the limits of the laboratory's equipment and the ability of the students—are arranged in order and written down. The teacher can then suggest desirable topics that do not appear in the students' list, can explain them to the class, and ask for their incorporation in the class list. The enlarged list thus represents the choice of both the class and the teacher. The students may now be asked to consult their textbook and laboratory outline to see whether the topics suggested are treated there; as far as possible the topics are now arranged in the order of the text. Then the class begins its work in the laboratory. Here, instead of maintaining a dead level of uniformity, which seems to be the goal in too many laboratory courses, the teacher should

encourage originality and alternative methods and apparatus. In order to reduce the cost of equipment, three or four students may often work together. But, however the teacher arranges his course, he should make it perfectly evident to his pupils that he himself is really interested in experimentation and that he is something more than a monitor over laboratory classes. When a topic has been studied as a laboratory problem, it should be taken up in the classroom. The teacher may himself give additional experiments as class demonstrations, or he may ask some of the pupils to do so. The class should make notes of what it has learned from all the experimental work; it should then be asked to study the material given by the textbook regarding the topic in hand and to recite upon it. Finally, from the notes on the experiments, from what other pupils, the teacher, and the text have contributed, each pupil should be asked to prepare an essay, or report, describing all he has learned regarding the topic. This should be neatly written and decently fastened together. The reports on such topics as gravity, weight, inertia, density, capillarity, the formation of drops may all be grouped together under some inclusive title, as "Matter and Force." As far as possible the minor topics should be put in the form of questions so that the report will be the pupil's answer to a definite problem or project. Illustrative questions are:

Why do bodies fall to the earth? Why does water rise into a towel? Why does water in a glass have a concave upper surface? Why does mud fly off from a revolving carriage wheel? Why does a candle burn? Is air matter?

But suppose the method just described is not possible in many schools because of the size of classes or the lack of laboratory space or equipment. The next best plan is what we may call the "cooperative demonstration method." And right here it may be remarked that most of the advantages of the laboratory method can be gained for the course, even if conditions are such that the teacher and a few students are the only ones who can actually carry out the more important experiments. The laboratory method, it must be remembered, is an attitude toward knowledge rather than a matter of tables, chairs and apparatus. If the laboratory work merely illustrates the textbook, the attitude of the student is not essentially different from that which he assumes in the ordinary lecture or recitation course. But if the experimental demonstration work of the teacher, and possibly of some of the students, is the *basis* of the introductory

science course, and if it brings the student face to face with the reality of phenomena, a truly scientific attitude may be aroused. The recitation must not be the basis of the course; it must be the means used to unify, expand, and illustrate what the pupil has learned in the experimental, vital way.

Suppose we consider a concrete case: How can the teacher without facilities for individual laboratory work present to his pupils the subject of centrifugal force? The project may at first be given a more common title, as, "Why does mud fly off from a revolving carriage wheel?" In the country or small town the title could be: "How does the separator remove the cream from the milk?" In opening this topic the teacher can ask the student to tie a string to a soft rubber ball and to whirl the ball in a circle, noting whether the pull on the string is affected by the speed of the ball. A rubber band may be used instead of the string; in this case the increase of the pull is shown by the stretching of the rubber band. The student may then be asked to let go of the string while the ball is being whirled and to note the course taken by the ball. He may then draw a circle on the board to represent the circle described by the whirling ball; also a straight line to show in what direction the released ball flies off. This may be repeated several times, so that the class can see that the freely moving ball always flies off in a straight line and that this is tangent to the circle at the place where the ball is released. The pupils should now be asked to think the phenomenon over and to report next day on something they have observed that shows this property of bodies to move always in straight lines and to pull against whatever makes them move in a circle. Some will think of the water flying off from a revolving grindstone, some of the dodging of one who is pursued in "tag," some of the difficulty experienced in making a sharp turn at a corner. Others, again, will have noted that running tracks and race courses are banked at the turns and that a railroad curve has the rail higher on the outside of the curve. Some boys may tell of the centrifugal slingshot of other days; they may even have tried the trick of swinging in a vertical circle a small pail partly full of water without losing a drop of water.

When these illustrations of centrifugal force have been discussed, it is probably time for some demonstration exercises on the part of the teacher or some of the pupils. If the school has a centrifugal apparatus of some sort (one can be made readily if none is at hand), the teacher can show the class how water

flies out to the farthest portion of a revolving globe. With this knowledge as a basis, some of the pupils should be asked to describe a cream separator. If the children are city-bred and cannot possibly see a separator in actual use on the farm, they should be asked to examine one at the store of some farm-implement dealer. Or a small, hand-operated separator may be borrowed for a day or two and brought to the school so that all the pupils interested, those in other classes as well as those taking introductory science, may know something of this useful piece of apparatus. The teacher may also ask a pupil to explain to the class the method of making the Babcock test for butter fat and, if the school has a Babcock apparatus, to make the test with a sample of milk. Other pupils may be asked to consult reference books to find out about the centrifuges in which crystals of sugar and salt are dried in the process of refining these substances. We have still, if we choose to make it a part of this topic, the explanation of the fact that the planets revolve about the sun in nearly circular orbits because of the combined influence of gravity and inertia. When the material gathered from the textbook, from the demonstration exercises of pupils and teacher, from the observation of pupils, and from commercial apparatus has been digested and arranged, the essay or report should be prepared as in the case of the laboratory method.

I have gone into these details regarding the science of the junior high school, even at the risk of boring you, because I have wished to bring to your attention the fact that introductory science can be real laboratory science, or if not, in the ordinary acceptation of the term, that it can be taught by a method which will still give it high pedagogical value. I wish now to express myself as forcibly as I may in opposition to the statement often made that the advocates of a general introductory science favor the substitution of such science for the special sciences of the senior high school. The outline, herewith given, of what I believe would be a successful sequence of sciences in the junior high school, senior high school, and junior college ought to dispel such a notion.

Suggested Continuous Course in the Physical Sciences.

Grade Science

7. Geographical Projects in Industries and Agriculture.
8. Introductory Science: Physico-Chemical Studies and Botanical Studies, each two or three times a week for one year, or five times a week for one-half year.
9. Introductory Science: Physico-Chemical Studies and Physiology (Including Hygiene), each two or three times a week for one year or five times a week for one-half year.

10. **Biology.**
11. **Physics.**
12. **Chemistry.**
13. **Advanced Chemistry**
14. **College Physics.**

As the outline shows, I believe that the seventh grade science work should be related to the work in geography, and yet lead more or less naturally to the introductory science of the eighth and ninth grades. The study of industries, correlated with work in history and English, can divide the time with the study of agriculture. The agricultural industries can occupy the autumn and spring, when out-of-door work is possible, while the manufacturing and other industries can be taken up during the winter months. Both the study of industries and that of agriculture should consist of a number of very practical projects, in order that they may hold the interest of the pupil and appear to him to be really worth while. In many schools the study of agriculture will be carried over into the eighth and ninth grades, alongside of the other science courses, and even into the senior high school. I have placed the introductory science course, consisting of both organic and inorganic science, in the eighth and ninth years. These may be given as a split course, each meeting two or three times a week, or the inorganic studies may be given during one semester and the organic during another. As a matter of fact, the two will often be closely interwoven. For the eighth year I have suggested physico-chemical studies and botanical studies; for the ninth year physico-chemical studies and physiology, including hygiene. Biological science would thus get four years of almost consecutive study of organic material; the physical sciences would get three continuous years and then an interval of one or two years before the special sciences, physics and chemistry, were taken up.

Why ought we to advocate the continuance of physical sciences and organic science through so many years? No one thinks of asking such a question of the teacher of languages or mathematics; these studies have always been allowed a continuous course covering many years, so that the proper impression could be made upon the student. What if science were taught as insistently as language or mathematics—might we not expect similar results? The repetition in language work is not an actual repetition of what was done the year before, but a progressive and constantly enlarging point of view. The student's increase in age and experience makes this possible. In the same way it

is necessary that there be a longer acquaintance with and use of science in order that the progressive enlargement of the student's point of view may go on; that the ideas of science shall accompany him along his road to maturity, expanding as he expands, changing for him from toy to comrade and from comrade to friend like the animal and boy companions of his early years. It is by this longer, more progressive association that he will see the facts and get the meaning of science, and will not know where his non-scientific self left off and his scientific self began; he will not remember the time when he did not think of his world, his activities, and himself in terms of the common-sense interpretations of science.

We now come to the third question raised in regard to the junior high school: What kind of a teacher is to teach junior high school science? This question has already been discussed in the general session of this conference. I am told that the school authorities in a prominent eastern state, coming to the conclusion that the college graduate is not specifically equipped for high school teaching, are disposed to advance the grade teacher of proper merit, and, after promotional work, into the junior high school, and later even into the senior high school. This will mean a serious change in the method of selecting high school teachers, for it will open a route to the high school that does not include the college in its itinerary. We need not go far to find the cause for this change. The college man has been wont to remark that his brother of the normal school fed the prospective teacher almost exclusively upon method, with only a minimum of content; the normal school man has replied that the college graduate had some facts, perhaps, but no method of "getting them across" to the student of the high school. We may as well admit that preparation of students for teaching is rarely the specific effort of the college; especially is this true of the science departments. But it will not do for us to let this condition continue indefinitely. The college must assume, it seems to me, the duty of preparing a much larger number of its graduates for science teaching. It must prepare them, moreover, not so much for the teaching of one science as for the teaching of several sciences, since by far the larger number will be obliged, for a time at least, to teach two, three, or even more sciences. The college cannot perform this duty adequately, in my opinion, unless it offers to intending teachers a course in the teaching of science. Such a course should be open to stu-

dents who have had at least one year in either college physics or chemistry and one year in a biological science. Completion of such a course, if united with any ability in teaching, ought certainly to furnish an adequate preparation for the teaching of introductory science.

The chief difficulty, however, in the way of successful science teaching in the junior high school will not be that the teacher has not the facts of his subject, but that he will lack the point of view and purpose of introductory science. He must remember that successful science teaching is not merely the adaptation of the teacher's mature knowledge to the immature student. It is not so much a matter of getting pupils to answer any particular set of questions as to get them to asking questions that are more and more intelligent. What difference does it make that the first answers are necessarily fragmentary and incomplete? As Professor John Dewey says: "General science may mean that a person who is himself an expert in scientific knowledge forgets for the time being the conventional divisions of the sciences, and puts himself at the standpoint of the pupil's experience of natural forces, together with their ordinary, useful applications."

The fourth question raised by the introduction of science into the junior high school is: Shall credit be given, toward college entrance, for junior high school science? The answer is that, while college entrance is based upon the fifteen unit system, beginning science is as much entitled to recognition as are beginning foreign language, mathematics, and English. If college entrance is based only upon the work done in the senior high school, the question answers itself. It may be interesting to have in this place the recommendation of the recent session of the Michigan Schoolmaster's Club to the faculty of the University of Michigan with regard to introductory science. The action taken is as follows, according to my information: "The conference recommends that one unit of entrance credit be given for high school general science to students who come from accredited schools, provided:

"I. The course is a full year's course.

"II. That 120 full sixty-minute periods are spent on the course, each laboratory period to count as one period of recitation.

"III. That laboratory work (consisting of demonstrations, individual work, or field trips) on the average of twice a week be done in connection with the recitation.

"IV. That for laboratory work there be available equipment used in the specialized sciences, together with what may be needed for general science.

"V. That the general science instructor shall, in addition, teach at least one of the specialized sciences, or shall have had one course of college physical or biological science.

"It is also recommended that where the course is half a year in length it be accepted as $\frac{1}{2}$ unit if accompanied by $\frac{1}{2}$ unit in physiology, hygiene, botany, zoology, or physiography."

At the upper end of the high school course another set of problems awaits us: those of the junior college. The establishment of the junior college, like that of the junior high school, represents at once the extension and the subdivision of old-time educational territory. To the high school it means the annexation of two more years of the student's time; to the large university it means the unloading of a considerable share of the burden of instruction during the freshman and sophomore years; to the college, if we are to believe some of the wild and excited cries that we hear, it means serious crippling, if not annihilation. That the college may need to readjust itself, if the number of junior colleges becomes very large, is very probable; that the college will improve under the new stimulus is certain; but that the college will have no work to do for the time to come is, in my opinion, not to be thought of.

You will note that in the outline suggested senior high school physics is placed in grade 11 and senior high school chemistry in grade 12. To many educators the reverse of this arrangement may seem better, but educational practice seems to be about "fifty-fifty," as our sporting friends would say. It may be worth while for teachers of physics to note the fact that, because of the forcing of high school physics into the twelfth grade, the demand for college physics has been greatly decreased, and that the average student who takes science courses in college rarely includes beginning physics. This is true partly, no doubt, because he feels that it is too difficult, but also because he feels that for him it involves needless repetition. Since college physics ought probably to follow freshman college mathematics, a two years' consecutive physics course would be practically impossible.

The arrangement suggested here leaves it possible for a student going from senior high school to junior college to have two consecutive years of chemistry. In such a case the junior

college teacher could really build upon the senior high school chemistry course—an achievement at present exceedingly difficult. The course in thirteenth grade chemistry could then be an advanced course in general chemistry, with the stress laid upon definiteness of theoretical conception, and a course in genuine qualitative analysis as well. When we consider that the popular demand of the future will be for more and more chemistry a demand due to the growing realization of its importance in household industries, manufacturing industries, agricultural industries, and for our national safety itself—we will not feel, even as teachers of physics, that such an arrangement is unreasonable. The greatest objection to it is probably that it places senior high school chemistry one year later than does the alternative arrangement.

In addition to the content of its courses, the pressing problem of junior college science, for the present at least, is that of giving as good instruction as the best given in the colleges with which the junior college competes or in the universities and technical schools with which the junior college is, in a sense, affiliated. In all of the junior colleges with which I am acquainted the quality of the work is being carefully guarded. The danger lies in the fact that the public, if it gets the idea that junior colleges are the thing, will not differentiate nicely between junior college work and two more years of high school work. The teacher of the junior college will need, therefore, to regard his position less of a public office and more as a public trust.

The value of the junior college science work, like that of the junior high school and senior high school, will thus depend mainly on the attitude of the teacher. We must remember that the college instructor, like his brethren in other fields of work, is "also," to quote a scriptural phrase, "a man under authority." He is expected, although he sometimes fails to realize it, to do a certain constructive piece of work. While the results expected from high school science are that the pupil who has studied it shall have interest, information, and a common-sense attitude toward the world, the quality expected of the college graduate is, more and more, *definiteness of knowledge*. This demand is being made, with constantly growing insistence, by the graduate school, by the industries, and by the great public itself. It will be no defense for the junior college to state that the four-year college is remiss in this regard; the four-year college is rapidly mending its ways, both because of its own dissatisfaction with

its present status, and also because of the call for a greater educational efficiency.

In conclusion, then, the enlarged high school needs most grievously, not laboratories and equipment, but an enlarging type of teacher; a teacher who has attainments, of course, but who has a great deal more: the vision to perceive and the will to perform his duty wherever he finds it, whether in junior high school, senior high school, or junior college. For we may be certain that our educational systems must adapt themselves to human needs, so that the boys and girls of today—the men and women of tomorrow—may gain more of self-knowledge and self-mastery, and may have a better opportunity to attain to that greatest boon of mankind, self-realization. We may be equally certain that in the reorganization and extension of the high school there will be little, if any, place for the mental and educational standpatter.

CLASSROOM SAYINGS.

"Ic" means no oxygen. "Ous" means less oxygen.

Cellulose is found in animal tissue.

Carbon dioxide is found wherever there is life in its natural form.

Iodine doesn't melt when heated because it decomposes.

The gas burns with an odorless flame.

To make monoclinic and rhombic sulphur—dissolve the brimstone in sulphuric acid, allow the acid to evaporate, and the monoclinic crystals will be found in the middle, the rhombic around the edge.

The bottle of carbon dioxide was tested with a burning splint which was distinguished.

Discuss the occurrence of fluorine compounds. "They occur in nature."

You make hypochlorites by passing the hydroxide into chlorine.

Student, attempting to follow directions in laboratory manual for precipitating magnesium ammonium arsenate, rubs the outside of the test tube gently for a few minutes without success—finally inquires as to the reason for rubbing the tube.

Question: What is the structure of a barometer?

Answer: One barometer is where a glass tube is on a board and has written out the side stormy, cloud and clear. The tube is filled with a white substance like lemonade. Wherever that substance goes that is the kind of wether there is going to be.

NOTES ON THE TEACHING OF GEOMETRY.

By Jos. V. Collins,
State Normal School, Stevens Point, Wis.

Historically considered, three fairly well recognized geometry textbooks may be distinguished: (1) That of Euclid, with its very difficult treatment of proportion in Book V, with its extended proofs of algebraic identities, and with its paucity of theorems in solid geometry; (2) Books like the French Legendre (1794, the name like Euclid itself often used as a synonym for geometry) with its simplification of the treatment of proportion and of other parts; (3) The recent geometries, with their wealth of exercises strewn in with the text purposing to be of more or less practical character. From the geometries of the Legendre type of twenty-five years ago, which had few or no exercises in the text, we have now swung to the other extreme. The sequence of the essential propositions is in a fair way to be lost when separated by a superabundance of minor exercise propositions. Most likely the pendulum will ere long swing back to some middle ground.

From the standpoint of their form and content, present-day geometries may be described under four classes: (1) Geometries in which both the reasoning and the reasons for the standard propositions are given in full; (2) Geometries in which the reasons are given in whole or in part but in which the reasoning is put in the form of questions; (3) Geometries in which the reasoning is given but the reasons are largely withheld; (4) Geometries in which both the reasoning and the reasons are developed in class by the instructor, the text being little more than a syllabus of definitions and propositions. Each of these types can be made a success in the hands of a good and energetic teacher, and each can be made a failure in the hands of a poor one. All of these types depend more or less on the exercises rather than on the theorems and problems to train the pupils in initiative and self-confidence, though this is especially true in the case of the first. All have serious advantages and disadvantages. The first is the most common type being used over most of the country.

An interesting and important question in geometry is, How shall the reasoning and reasons be presented as related to each other? In the old geometries of the Euclid and Legendre types, the reasoning and the reasons were interwoven and printed in the same type. Wentworth scored a hit by printing reason-

ing and reasons in different type, the latter between the former, though often giving reasons at the right margins as references without quotation. Some recent geometries place the reasoning on the left half of the page and the reasons at the right, matching them with corresponding numbers. It is hardly to be doubted that the best plan is to place the reasoning at the left of the page with the appropriate reason following that to which it belongs but in different type and in parenthesis to set it off as different from the preceding text. This course gives greater flexibility, since part of the time more space is needed for the reasoning and less for the reasons, and vice versa, and besides it makes the reading of the page more natural.

Why geometry is studied is a practical question of considerable importance. Three reasons may be given: (1) It is studied to furnish a general training in reasoning or logic; (2) The knowledge of form, magnitude, and numerical relations acquired has practical value for all; (3) Geometry is a necessary preparation for any more advanced study of mathematics. All studies have more or less value for the training of the reasoning and sense perception, but geometry gives a special training in these not acquired from other studies, and this training is needed to supplement the other forms. No other reasoning is so dovetailed together, so expanded in closely woven, connected form, and no other requires such intent application for its mastery. A little reflection shows that there is no material other than the half dozen fundamental concepts of geometry, the point, line, plane, solid, and angle, which furnishes data for reasoning that is simplicity itself but which yet admits of being developed into a beautiful science giving a tolerably full and clear illustration of the great fundamental laws and principles of logic.

In this country the value of geometry in the educational curriculum is pretty sure to come up for discussion in geometry classes. It is not wise to allow any prolonged discussion of the question, not because the case for geometry is weak, but because high school pupils are not competent to sit in judgment on the case, and because the strongest grounds for the teaching of geometry are like many of the strongest forces in society—more or less intangible. You cannot put your hands on them and weigh them. Probably the best and a sufficient answer to give a class is to say that educational leaders the world over recognize the value of the study, and secondary school systems

generally require it. If geometry really did not deserve the place it occupies, the fact would have been found out long ere this. The decision of this important matter cannot be left wisely to local pedagogues to decide. They are hardly competent.

It is probably true that most geometry classes contain a percentage of members varying above or below 20 per cent that are little profited by the study and may even be injured by it, under the guidance of the average teacher. A remedy should be found for this situation. One is proposed in an article bearing the title "Adaptation" in the *Educational Review* for March, 1916. Pedagogical methods in teaching geometry are highly important.

Whether the class exercise should be oral, written, or a combination of the two depends on the size and character of the class and can be made a matter of experiment. Three methods of presenting the subject may be described, each the antithesis of three others. (1) The didactic or telling method *vs.* the heuristic or questioning method. These two may be used either in parts of a proposition, throughout demonstrations, or throughout the subject. Naturally one thinks of the questioning method as superior to the other, certainly for oral instruction; but all the old geometries evidently use the didactic method in presenting the standard demonstrations. It is true, of course, that sometimes one is better and sometimes the other. (2) The analytic *vs.* the synthetic method. By the synthetic method the author studies his proposition and then presents it to the learner in the most direct and convincing way possible. The learner is told nothing of why the demonstration takes the form it does. By the analytic method, on the other hand, a preliminary study is made of why the demonstration or construction takes the form in which it appears. Thus, the synthetic method tells how to bisect a line or angle. The analytic method says the line cannot be measured in linear units nor the angle in degrees and then be halved numerically, since each is quite sure to be incommensurable to a standard unit of measure; and that only the circle and straight line postulates are at one's disposal for use, whereupon the construction becomes natural instead of apparently highly artificial. By the synthetic method, the method of dividing a line in extreme and mean ratio is first shown and this is later used in inscribing a regular decagon; by the analytic method, the whole process is reversed, by using a

figure supposed to represent a decagon inscribed in a circle and working back. (3) The Euclidean *vs.* the genetic methods. Euclid selects his 160 odd propositions to make a logical chain and sets them down in the best available order. By the genetic method one begins, for example, the Book on Polyhedrons by trying to get the surface and volume of a pyramid and is led by logical steps to the whole chain of propositions of the Seventh Book. The proposition to prove two triangular pyramids that have equal bases and equal altitudes equal, with its strange Pyramid of Gizeh steps, becomes a natural and necessary link in the chain, as does also the proposition that proves an oblique parallelopiped equal in volume to a right parallelopiped having an equal base and the same altitude.

Training in the making of geometrical definitions has high educational value, as seems to have been recognized by the philosopher Plato. For these definitions an oral recitation appears to prove much less satisfactory than a written one. At any rate, the teacher should experiment with both. On the subject of geometry definitions, attention is directed to the importance of requiring the pupil to give definitions as reasons as well as propositions as reasons. Special attention is called to those for parallelograms and similar polygons. Pupils persistently fail to distinguish between what is known by definition and what is known by proof about these figures. The teacher may expect to have a fight at this point. An article by the writer in the November, 1910, number of the *Popular Science Monthly* brings out the following points about mathematical definitions: (1) Authors of geometries differ on essential points, some presentations being much superior to others. (2) Authors of dictionaries very often give vague and shifty definitions of geometry terms. If *they* do, pupils are excusable, certainly at first. (3) The dividing line between axioms, postulates, and definitions is often not clear. The article is in error at one point. It states that Euclid retained the word postulate for postulates of construction. It should have said recent English Euclids do, but not Euclid himself. There are only two postulates of construction, namely that of the straight line and that of the circle.

It was thought by many in former times that the number and order of the propositions was fixed and could not be changed. But from the time that Legendre broke away from the established path, the bars were let down for anyone to lay out his own geometry. With this has come both advantage and dis-

advantage. This is especially true in Book One. The best educational thought within the past few years would avoid the formal proofs of the very simple early theorems, replacing such perhaps by sentences which contain the gist of the proofs.

As an illustration of the superiority of Euclid over his modern rivals, we may take the case of the treatment of parallels. Euclid proves first that an exterior angle of a triangle is greater than either of the opposite interior angles. Then it is very easy for him to prove that if two straight lines are cut by a transversal, making the alternate interior angles equal, the lines are parallel. Next he proves the converse of this last by use of his 12th postulate, over which the controversy has raged, namely: If two lines are cut by a transversal, making the sum of the interior angles on one side of the transversal together less than two right angles, the lines if sufficiently produced will meet on the side on which the sum of the angles is less than two right angles. With these three theorems proved, which is easily accomplished, particularly if Playfair's axiom is used instead of Euclid's 12th postulate, the rest of the propositions about parallels readily follow.

Compare now Euclid with his modern improvers. Ordinarily they begin by proving first, that if two lines are perpendicular to the same line they are parallel; next, if one of two parallel lines is perpendicular to a third line the other is also. This latter proof is indirect; it has to bring in Playfair's axiom, namely, that two intersecting lines cannot both be parallel to a third line. This proposition with its proof is something of a puzzle to a beginner; next, by drawing a perpendicular through the middle point of the transversal it is shown that if two lines are parallel and are cut by a transversal, the alternate-interior angles are equal; lastly, the converse of this is shown by the indirect method.

Euclid's method has another advantage in that it serves as an introduction to the non-Euclidean geometry. After a class has had plane geometry and is reviewing, reference can be made to this non-Euclidean geometry. H. P. Manning's book on this subject can be studied as an introduction to the ideas of this geometry.

Along with the notions of the non-Euclidean geometry the subject of the dimensions of space can also be taken up. A considerable amount of matter on this subject has appeared in periodic literature in recent years. Perhaps it would be sufficient

to have reviewed the prize essay that appeared in the *Scientific American*, Vol. 101, p. 6, July, 1909, on the "Fourth Dimension of Space."

The greatest conundrum at the present time in the teaching of geometry is the best way to deal with incommensurables and limits. Classes that are at last beginning to get on their feet when they reach the book on circles are knocked breathless by the theory of limits and its applications. Geometry without the theory of limits treatment of incommensurables is little better than an advanced arithmetic. Probably the best course to pursue is for the teacher to make very plain that incommensurables are the rule and not the exception in the theory of measurements. This can be made pretty clear by pointing out that there is an infinitely large number of points between any two 32nd inch marks on a rule, and it would be difficult to decide at which one of these points an object taken at random being measured ends. Thus the impossibility of measuring objects in the perfect way demanded by geometry is apparent. For instance, if a line taken at random were measured with the inch as a measuring unit, its length might be represented by 3.87590457 . . . with a never ending row of figures. If a diagonal of a square is measured with its side as the measuring unit, it can be shown that the square root of 2 represents their ratio and this is a number of the kind just described.

Having made the nature and reality of incommensurables clear, the teacher will do well to give merely the demonstrations himself and not require the pupils to prepare them. In this way the study of these limit propositions can be held back till after the Fifth Book is reached. Then, if so desired, the class can be asked to work up the limit propositions, so as to be able to give them. In the Second Book the real practical meaning as usually explained in the scholium of the proposition which says, "The ratio of angles at the center of a circle is equal to the ratio of their intercepted arcs," should be carefully made plain.

A study of the most common errors should be made. Of these the petitio principii, or reasoning in a circle, stands out most prominently. If persons commit this error in geometry where the act ought to be so apparent, what must they do in other reasoning. One way to illustrate the futility in such reasoning is to talk of a man lifting himself over a fence by catching hold of his bootstraps! Another error familiar to every teacher is proving

a proposition by the use of one that comes after it. Here the illustration that can be used is that of a chain made up of links, or of a wall made up of bricks. One cannot lay a brick on one above it, or support a chain by fastening its end into one of its own links. A third form of error is proving a special case and regarding the proof as general.

If geometry is the logic of the elementary and secondary school, then the teacher cannot be too careful to connect geometrical reasoning with that of everyday life.

A fourth common mistake is proving a proposition by reference to the converse of the proposition really needed. That a converse proposition does not follow from the proposition itself should be thoroughly illustrated until the pupil sees the force of the contention.

Every teacher of geometry should read some good history of mathematics like Cajori's or Ball's and also books on the teaching of geometry such as Smith's *The Teaching of Geometry*.

He should also read Hilbert's *Foundation of Geometry*.

SILVER FROM TEXAS MINES.

The United States Geological Survey, Department of the Interior, reports that the Presidio silver mine, in Texas, was in continuous operation during the first six months of 1917, that mining was also carried on during that period in the Van Horn and Sierra Blanca districts, and that several shipments of copper ore were made from deposits in the "Red Beds" of Foard and Knox counties. The result was a small output of copper, lead, and zinc, but a production of silver for the six months of fully 340,000 ounces.

CREDIT OF HIGH SCHOOL PUPILS.

Editor SCHOOL SCIENCE AND MATHEMATICS:

Will you not give space in SCHOOL SCIENCE and MATHEMATICS for a discussion of the proposition to vary the credit given pupils in the high school courses, in accordance with the varied quality of work done in a given subject. Our present method of giving the same credit to all passed in a subject appears to me both unjust and foolish. Four different marks are given pupils in the Chicago high schools—A, B, C, and D. No credit is given those marked D, and the same credit is given each of the others. In my opinion, some credit should be given the better D's—about the same to the poorer C's—and more credit given the B's and A's than is given the average C. I have been told that there are high schools in the country which follow the scheme I have mentioned. Will not teachers in such high schools tell us what they think of this plan; and will not some of those who are opposed to the plan give us their objections?

I cannot imagine anyone who will refuse to admit there is almost an unmeasurable difference in the efficiency of those pupils marked A and the poorer C's; in my own case, I should say between the A's and any of the C's. The difference is like that between some capable research scientist and the ordinary amateur playing with science. The great majority pursuing any given course never get a usable grasp of the principles of the subject. In such cases there can never be any creditable work done in applying them. Only the B's and A's are trustworthy problem solvers; and of these, the A's are much superior.

Almost everywhere else we do quite differently about the differences in people or in things. In industry and government the most efficient are paid from ten to a hundred times as much as the inefficient. In commerce we grade foodstuffs, building material, and what not, and the better grades exchange hands at a price often ten times as great as the price of the poorer quality. In the high school we give but one price. If the pupil falls a little below what the conscience of the teacher will allow him to pass on, he gets nothing. If he pass at all, he gets as much as the most capable one pursuing the subject, though values of the work done may indicate a difference of efficiency in the subject as great as that between a Newton and a mere tyro.

The only recognition we give superior work is to allow the pupil to take an extra subject, and so run the risk of materially lowering the quality of his work and of ruining his health. To give increased credit for better work in the same subject, in my opinion, would be much the wiser and better for both the pupil and society. It would be a wholesome stimulus to each pupil to do his best, and would aid in the discovery of the more capable individuals in all lines of activity.

JNO. O. PYLE,
Teacher in Mathematics, Harrison Tech. High School.

REPLY BY THE EDITOR FOR CHEMISTRY TO A LETTER ASKING WHAT "PRACTICAL" CHEMISTRY IS TAUGHT IN HIS COURSE.

My dear Mr.———.

Replying to your questions about our chemistry department let me, like a true Yankee, inquire first what you mean by "practical work." Some of us, who have thought a good deal about the matter, are beginning to think that about the most practical thing in the chemical world is chemical *theory*. As we watch so-called chemists at their daily routine we find that they are one and all following, sometimes blindly, methods that have been worked out for them by the few real chemists who have taken the time and put forth the effort to become thoroughly familiar with the broad fundamental principles and the helpful theory of chemistry. I note, too, that even from the standpoint of salary these big chemists get the big pay while the "practical" fellows have hard work to exceed $90 a month.

Now there is very little that can be done in a first year course in high school chemistry that is really practical in any true sense. It is easy to fool the pupil (and the public which pays the bills) into thinking that "practical" chemistry is being done in the high school, but when you consider that we have 100,000,000 people in the United States and only about 10,000 chemists you will see that if you are planning to make chemists of all your pupils you will soon overstock the market.

The things which are done in high schools in the name of practical chemistry are usually things that the pupils will never need to do for themselves in real life—things which not even real chemists do for themselves. For example, very few chemists make their own baking powder. They can get better powder than they could readily make and get it cheaper, in the regular trade. Each baking powder manufacturer needs, and has, a trained chemist, and the latter serves thousands of people in a most practical way by controlling the output of his factory. Similarly, all large soap manufacturers have chemists to control their soap production, and the making of soap in the high school laboratory, while interesting, and capable of being used to teach certain fundamental principles, is far from really being practical chemistry.

The testing of food stuffs by high school "chemists" is another of the very popular pastimes that pass as practical chemistry. We find in Indiana that Mr. Barnard, our Commissioner of Foods and Drugs, who is a real chemist, with the help of a half

dozen or so other real chemists, can very nicely control the character of foods and drugs offered for sale in the state without much assistance from us high school people. Some of our graduates have been made assistants in his laboratory and then have later gone on to college to become real chemists, and several have then been given responsible places in the state laboratories, but thousands have taken our course in chemistry without ever becoming chemists. So you see I am inclined to look out for the needs of the 99 per cent, and they surely do not need the so-called practical chemistry. Why not try, rather, to give our pupils some notion of what chemistry is about, what it has done and is doing in the world; to give them enough of an understanding of the subject so that they will know when they need the services of a real chemist in helping solve the problems that will come to some of them as manufacturers, or business men, or farmers, or doctors, or lawyers? We also hope that they will become intelligent in regard to many matters in which the public as a whole is vitally interested, such as sewage disposal, the obtaining of pure drinking water, the getting of cheap and good illuminating gas (we get ours at 55 cents per 1,000 feet here because of an enlightened citizenship) and many other things of this nature. These are some of the *really practical* things that we are trying to do. Incidentally all the pupils who go to college get plenty of preparation to satisfy the entrance requirements and, better than that, if they are of average ability and apply themselves, they score high standing in their college chemistry classes because we have taught them to *think chemically* instead of trying to pack their heads with "practical" information. The college professors all tell me they very much prefer that type of training. The practical chemists of this city who hire many of our pupils as assistants all tell me, too, that *they* prefer to teach the *specific chemistry* and the *methods in use* in their plants, and that they want *me* to teach the *fundamental principles* and give the pupils the *correct habits of thought and of work*, which the school is better fitted to do.

Now I wonder if this is the kind of answer that you expected to get? I may add a few specific notes as to some of the things that we do in our course, things which might be suspected of being practical, but which we really include because we can thus teach, in an interesting manner, some important principles of chemistry.

For example, we study smoke production in order to study smoke prevention, and we go *in school time* to various factories to

see various types of practical smoke prevention devices. We visit our municipal gas plants and our city water-filter plant. We visit laundries and study the softening of hard water and make tests of the laundry water before and after softening. We study the methods of bleaching in use at the laundries that we visit. We go to see oxy-acetylene welding done by practical workers, and we visit glass factories and other chemical industries, such as sulphuric acid plants. All these things help our pupils to become educated in many vital matters and we believe such work is "practical" in a very real sense but we make no pretense of training chemists. In the laboratory we make many substances of practical value such as baking soda (which we make from common salt by the same process that is used by the great Solvay Company), washing soda, caustic soda, sulphuric acid, hydrochloric acid, soap, baking powder, etc., but we do not let anybody think that it is practical to attempt to make any of these things in competition with the great industries that market them. We are more intent on giving our pupils a chance to understand some of the fundamental laws and principles that they, in common with the industries, make use of in producing these substances.

Have I made clear my point that there is bigger business at hand for the high school chemistry department than the imitating of certain alleged "practical" processes and tests? The latter type of work is seldom of any real practical value to those who perform it and it may be, and frequently is, done without the need for much hard thinking, and without a ghost of a notion as to what is really going on.

Hoping that, whether you agree with me or not I have given you something to think about, I am,

Sincerely,

FRANK B. WADE,
Head of Chemistry Department.

STRONTIUM ORE PRODUCED IN THE UNITED STATES.

For the first time in many years strontium ore has been marketed from deposits in the United States, according to J. M. Hill of the United States Geological Survey, Department of the Interior. Most of the ore marketed in 1916 was produced in Arizona and California. The ore mined in the state of Washington was not marketed. The domestic output was equal to about ten per cent of the ordinary demand, which amounts to two thousand tons. The British embargo on strontium salts need cause little disquiet among American users, for abundant ore is no doubt available in this country, and certainly American chemists have shown that they can profitably make the salts needed here.

A METHOD TO APPROXIMATELY DETERMINE THE WEIGHT OF AIR.

By W. J. Bovee,

Manual Arts High School, Los Angeles, Cal.

Most of our physics textbooks tell us to use methods more or less difficult in determining that air has weight. They all embrace the use of an air pump. To one who is acquainted with the laboratory equipment of various high schools this immediately suggests great difficulties.

On the average there isn't one school in ten that can be entered at any time and found to have an air pump in workable order. When the chapter on air pressure is approached, usually a half day is required to overhaul the pump. The resulting accomplishment usually places the teacher in the same state of mind of the student that has with great difficulty solved a problem. In this glow of elation, the students are allowed to play with the pump with free abandon—to the detriment of the pump and the next time it is needed.

Is it any wonder that some teachers, who see another class approaching, place a lock and chain on the pump? Now some teachers will raise their hands in great horror at the mere suggestion of such curtailment of student knowledge. Yet in the end possibly a greater accomplishment is obtained—by thus having the student get the impression that air pumps are workable—than the impression now obtained in the average school.

As the average pump has no mercurial attachment to show the relative amount of vacuum obtained in a weighed flask, one labors in the dark when using this method. A thousand and one things seem to enter for the purpose of causing the teacher to apologize for mistakes that might occur.

A much easier, more quickly accomplished method, with satisfactory results, was obtained by using burned-out electric light globes. A student was assigned the task of finding the amount of vacuum in a 32-candle-power globe, and the cubic centimeter content of it, as a class demonstration.

A large glass battery jar was almost filled with water. The electric globe was immersed in this, with the ends parallel to the table so that any residual gas in the globe could not escape. A pair of pliers was placed on the glass tip which is on the large end, and with a firm, prying motion the tip was broken off. Thus a small hole was made in the globe, and water rushed in to fill the

partial vacuum. The unfilled space in the globe was the unexhausted gas left when the globe was made.

The globe was removed with the ends still parallel to the table to prevent the loss of the residual gas, until out of the water, when the broken end was turned up. A small funnel had previously been prepared by heating the tube end in a Bunsen flame and drawing it out to a small bore so it could be placed in this small hole in the globe. A graduate was used to measure the amount of water required to be poured into the globe through this funnel to displace the residual gas in it. As this gas remains in the broken globe, it is necessary to subtract it from the total volume of the globe so as to find the volume of the air and its weight that enters the globe in the following method:

Another globe of the same size and made by the same manufacturer had been prepared previously by breaking off the glass tip on the end so that air could enter, and then, with a sharp knife, the brass and cement had been removed from the other end. Thus the little glass depression was exposed, through which the wires enter the globe. As this would later become filled with water, but should not enter the problem, its cubical content was found by filling it with water from a graduate. This memorandum was labeled A. Then an ice pick was taken to punch a hole through the little tube where the platinum wire goes through into the larger globe. Care must be taken to hold the globe in the hand during this operation, or the globe may be broken. The globe was then filled by immersing it in water, with one end up, as there is a hole in both ends. Its cubical content can then be easily measured by emptying into a graduate, and by subtracting the amount of the residual air, and the amount labeled memorandum A, the cubic centimeters of air that enter the globe can be found. This is usually around 275 cc.

From one to four globes of the same size and manufacture as used above were placed in new paper bags and carefully weighed. Each will average in weight from 50 to 55 grams, but should be weighed to the hundredth part of a gram if possible. Then the glass tips were broken off with the pair of pliers while the globes were in the bags, so that the bags would catch any little pieces of flying glass. Each globe should increase about thirty-three one-hundredth parts of a gram, according to the manufacturer.

As all globes are made in the same form, they are practically the same size and vary but little. With the known cubical content of the globes used, and the increased weight when air is

admitted, the weight of 1,000 cc. of air can be calculated, which should be around 1.20 grams per liter at room temperature, 20° C. As every high school laboratory has a balance that weighs to grams, by using four globes in the above manner very satisfactory results can be obtained.

SCOPE AND DIVISION OF THE FIELD OF SCIENCE.

By Rolland Merritt Shreves, Ph. D.

Kearney, Nebr.

The scientist is not dealing with matter foreign to our life, but with the very facts of our experience as his data or materials. The range of science is the whole range of human experience, but we are to grow more specific in our statement as to what we mean by the range of human experience. The field of science is the phenomenal world, or the world of time and space, the fact world. This must not be lost sight of, for it is the most essential guide-post to our further statement of the world of science.

For practical purposes the field of science has been divided into a number of special fields, and developments are now made along each one separately. Gradual growth and development has led to this differentiation of function, or division of labor, among the scientists, and this division has been brought about as a result of the specialized interests of our individual wills. We shall later see that the whole creation of science is the product of the demands of our practical will, or the concrete expression of a life of purpose. The scope of science must be broad enough to include the special fields of all the subordinate sciences. We shall look for a moment at the special fields, namely, the physical, biological, sociological and psychological.

The physical sciences have as their aim that of giving a complete descriptive account of the facts of experience, so far as these are yet analyzed, in the world of inorganic matter. This field includes the special sciences of physics, chemistry, geology and allied sciences, and their applied forms. These sciences are alike in that they all attempt to describe and explain the facts of human experience. They are unlike in that each science has its special aim and field, or range of facts which it considers.

The biological sciences have the same general aim as all science, to give a description and explanation of the facts of experience. But here the facts lie in the organic rather than in

the inorganic world. The special sciences in this field are botany, or the science of the plant as a living organism; zoology, or the science of the animal organism; and physiology, or the science of the human organism. It will be observed that the biological sciences deal with life, or the organic world; while the physical sciences deal with the inorganic, inert world of matter. These two fields divide between themselves the whole world of material science. The biological and the physical sciences are alike in that they deal only with matter and not with mind. The sciences of mind must now be mentioned in their relation to the whole field, or scope of science.

The field of psychology is the whole range of consciousness, whether in plant, animal, or man. And in this great field are found many divisions, but the aim is always one, and consistent with the aim of science generally. The special aim here is to give a careful and scientific account of the states of consciousness in their relation to each other and to life. The aim is not to show the meaning of our ideas for reality, but simply to give a descriptive and explanatory account of them.

Here the difficulty of explanation is much greater than in the physical and biological sciences, for the reason that the causal relationships cannot be discovered between ideas, or states of consciousness, in the same way as is possible in the material world. One idea is not the cause, and another the effect. This causal relationship is not traceable between states of consciousness. The demand for explanation of mental phenomena, then, must be satisfied in quite a different way. This is done by the hypothesis that every state of consciousness has a corresponding physical process, and receives its explanation by relating it to the proper physical or nervous process. Technically stated there is no psychosis, or mental activity, without a parallel nervous process, called neurosis, and each psychosis is explained by reference to the neurosis that forms the other side of the psycho-physical process.

The only way that a scientific explanation of the states of consciousness is possible, at the present time, is by relating each mental process to a process of nerve action. This explanation is not causal, nor is it teleological or ideal, it is explanation through correlation. The action is none the less intelligible as explained by this psycho-physical correlation. And it is greater intelligibility that science tries to give to the world, through analysis, synthesis and explanation. Science tries to make the world in

which we live rational, orderly and thus intelligible. This is the demand of our will to live giving expression to itself in a practical and concrete way.

The social sciences also aid in giving to the world greater rationality and order. History and sociology have here a great work in explaining social phenomena. In the past, history has been too descriptive at the cost of intelligent explanation, but this only indicates the puerility of this science, and suggests that the final history of neither the world nor any part of it has yet been written. If history is to be merely descriptive it has no hopes of becoming a science. If it is to be explanatory as well, and this is essential to its being a science, it cannot afford to leave us to guess the cause of the phenomena with which it deals.

Sociology is also young as a science. It would not even deserve the name of science if its intentions were not so good. On faith we may, then, regard it as a science of the future, and its field will be to describe and explain the phenomena of social or group life. It must show the laws operative in the formation and maintenance of the group relationship. Inasmuch as these laws must necessarily be psychological, sociology must draw heavily on social psychology. In fact this is about as far as sociology has gone today. It will certainly make more independent advances in the future. It must gather carefully its own data of social life, and classify, correlate, describe, and explain these phenomena.

The abstract sciences of mathematics and logic deserve special mention in any attempt to classify or group the sciences now known to man. These are not physical, psychical, or psychophysical, inasmuch as the data of both these sciences are not things or ideas, but pure relationships. In the case of mathematics time and space relationships are the elements involved, the phenomenal world is the basis. In the case of logic, ideal relationships are involved, or the truth of our ideas and thoughts constitutes the ground of its search. Logic, however, goes beyond the limits of mere description and explanation and has a teleological reference. We must, then, leave further statements regarding logic out of consideration here.

Mathematics is the science of time and space relations. Its data are simply these immaterial relations. It is thus an abstract science, or in a sense ideal. The aim of this science is, however, consistent with the aim of science generally, that of giving an explanation of the world in which we live, so as to make it more consistent, less fleeting, and more intelligible.

There is another great and important group of inquiries often called sciences, but their aim is so different from all the groups mentioned above in this article under the head of descriptive sciences, that careful distinction must be made here, even though we must be very brief. I refer to the philosophical disciplines, or the several branches of philosophy, namely, metaphysics, epistemology, logic, ethics, aesthetics, and philosophy of religion. These are sciences, in that they have their own respective fields of enquiry, and collect, systematize and explain their respective data. But all this is incidental and preliminary to the real purpose of these sciences, which is to show the meaning of all this for life. It is meaning here, and not pure description and explanation, that we are seeking. In distinction from the descriptive sciences these are called normative, and particularly for the reason that each one sets up a standard, so as to give meaning and value to life. The word normative means a standard or norm. Metaphysics gives us the nature and standards of being and reality; epistemology, the nature and standards of knowledge; logic, the standards of correct thinking; ethics, the nature of goodness and the standards of conduct; aesthetics gives us the nature and standards of the beautiful; philosophy of religion, the standards of right religious conduct and belief.

We have observed already that the field of science is very broad in that it includes the phenomenal world of matter, the physical and biological sciences; the world of mind or consciousness, the psychological world; and the world of mind and matter in their relations, psycho-physics; and finally the world of pure and abstract relationships of time, space and ideas. And in its broadest significance science includes the philosophical disciplines, which we have called the normative sciences.

INCREASED GRAPHITE PRODUCTION.

The production of flake graphite has increased steadily during the last three years, owing to the great demand for it for use in making crucibles. H. G. Ferguson of the U. S. Geological Survey, Department of the Interior, estimates that the production of flake graphite for 1916 was about 11,500,000 pounds, as compared with 7,074,370 pounds in 1915 and 5,220,539 pounds in 1914. Alabama furnished about 5,500,000 pounds, and the remainder came from mines in California, Montana, New York, and Pennsylvania. In all sixteen companies produced flake graphite. The imports of flake graphite, chiefly from Ceylon and Madagascar, far exceeded the domestic production. Owing chiefly to the immense demand for crucibles for use in making munitions, the better grades of flake graphite now command more than double the prices at which they sold before the war.

Most of the amorphous graphite used in this country is imported from Mexico.

THE INDUCTIVE METHOD FOR LAYING THE "FOUNDATIONS OF ANALYTICAL CHEMISTRY."

By I. Newton Kugelmass,

Dept. of Chemistry, College of the City of New York.

Science is usually regarded as the exact and systematic statement of our knowledge of a subject. If we accept this definition the study of chemistry becomes the acquisition and arrangement of those facts and principles which give adequate expression to this branch of science. The trend of science teaching, however with the growing tendency to give more heed to the methods of teaching, is toward a deeper, more liberal and vital conception. To the modern teacher whose work is a potent factor in the problem of education, science is not only the investigation and comprehension of truth, but is the correlation, systematization, and interpretation of truth. The inadvertency of one or another of these latter stages in laboratory procedure has called forth this symposium.

The course in general inorganic chemistry in the main extends through two semesters. The essence of the laboratory work of the second term is the study of the typical metals and their compounds, with a view towards laying the "foundation of qualitative analysis." The solubilities of the chlorides, sulphides, carbonates, etc., are tested at different laboratory periods, one experiment having no bearing on another, although the procedures are simultaneously analogous, e. g., without any systematization, and correlation—the steps most essential to the logical comprehension of the "substratum" of qualitative analysis, the steps which will give the student the apperceptive basis. Let us see how the student himself can build up a qualitative analysis, how these, the usually omitted of the Herbartion steps, are included.

After each experiment on the solubilities of the chlorides, sulphides, etc., the student should classify and thereby compare the properties of each in accordance with a skeleton chart similar to the one on the next page:

In the laboratory it is the function of the teacher to use the quiz-demonstration method for individual students or groups in order to build up the specific ideas, make them clear and explicit by "questioning into their minds and questioning out of their minds" the bases of separation—the differences in the physical and chemical behavior of the substances utilized for the purpose of separation. A magnificent pedagogical oppor-

THE SULPHIDES.

Metals	Sulphides	Color	Solubility in H_2O	Sol in HCl	Sol in HNO_3	Sol in H_2SO_4	Sol in $(NH_4)_2S$
Hg.							
Pb.							
Cu.							
etc.							

tunity awaits those teachers who are the faithful servants of the science of chemistry, who believe that it is their personal contact with pupils working in the laboratory under favorable conditions which results in good habits of observation, teaches the difference between accuracy and vagueness, inspires a belief in the utter inadequacy of all abstract verbal accounts of real phenomena, increases mental self-reliance and shows that harmonious action of hand and mind is mental rest.

The solubilities of the essential compounds having been tested, the student is in possession of classified data for each. To get a broader vision of the aim of these specific tests, to correlate the whole mass of accumulative data, the student is now required to fuse the individual tables into one aggregate—the chart of the analytical groups, the result of his own investigation. This lays the real foundation of analytical chemistry.

In conclusion: Chemistry is gradually taking the boldest stand among the sciences. It is the duty of its teachers to accelerate its remarkable growth. It is they that must fit the science for its place. "Teachers, have guidance of an analytical kind to assist in the finding and study of all the points to be considered in each experiment. Have guidance of a synthetic nature to stimulate the inter-relating of various facts and views brought out by present and past experiments. All this is necessary in order that the instruction may be an imparting of organized knowledge and not a jumble sale, and that, with the acquirement of an ever-tightening grip on the inner spirit of the science rather than an ever-growing collection of ragbag odds and ends, the pupil may advance in the profundity as well as the area of his knowledge." Make chemistry a purposive and prob-

lematic study, and thereby develop critical powers by comparison, discrimination and reasoning.

THE ANALYTICAL CLASSIFICATION.

Group I pptated by HCl includes the	*Group* II pptated by H_2S includes the	*Group* III pptated by $(NH_4)_2S$ alk. with NH_4OH includes the	*Group* IV pptated by $(NH_4)_2CO_3$ includes the	*Group* V not pptated. includes
Chlorides insol in H_2O and HCl.	Sulphides insol in H_2O and HCl.	Hydroxides insol in NH_4OH and NH_4Cl and Sulphides sol in HCl & insol in NH_4OH	Carbonates insol in NH_4OH and NH_4Cl	All compounds soluble in H_2O.
Pb. 1......... 2......... 3.........	1......... 2......... 3......... 4......... 5......... etc.	1......... etc.	1......... etc.	1......... etc.

NOTE: Insert name of metal whose compounds are insoluble in the respective reagents as given in each column.

Omit in a column those metals already placed in column before.

OIL USED BY RAILROADS.

A decided increase in the use of petroleum as locomotive fuel by the railroads of the United States in 1916 is shown by statistics compiled under the supervision of John D. Northrop, and just published by the United States Geological Survey, Department of the Interior.

Reports submitted by fifty-three railroad companies, comprising all that operate oil-burning locomotives in the United States, show that the quantity of oil fuel so consumed last year was 42,126,417 barrels, a gain of 5,477,951 barrels, or fifteen per cent, over the consumption in 1915.

This increase shows the steady expansion in the United States of the market for low-grade petroleum from Mexico rather than any appreciable increase in the use as fuel of low-gravity crude oils from domestic sources, whose value for refining is just beginning to be recognized.

The total distance covered by oil-burning engines in 1916 was 140,434,566 miles, and the average distance covered per barrel of fuel consumed was 3.33 miles. Oil-burning locomotives were operated in 1916 over 31,980 miles of track in twenty-one states.

SOME IDEAS ABOUT HIGH SCHOOL ALGEBRA.

By Wm. B. Borgers,
McKinley High School, Chicago.

Algebra is a tool, indispensable for geometry and physics, either as they are studied in school, or as the live citizen uses them in practical work. And unless the student can have more than one year for the study of algebra, we have not time to teach it except as such a tool. However interesting an elegant solution of a problem in six unknowns may be, we know that the student will never meet with a concrete problem in more than three, and that there is not one chance in a million outside of solid analytic geometry of his ever having one with more than two unknowns. Therefore, with a sigh of regret, let us resolutely cut out everything beyond two unknowns, and not try to go very deep even into two. Ransack the sources of concrete problems with which he will ever meet (without taking college mathematics), and those that are not most easily solved with one unknown are very few; and for those few, the equations will not be intricate.

Under the binomial formula, if he can expand powers of $x \pm y$, without coefficients or exponents, and square any binomial, that is plenty. What a pity to demand that he shall give the rth term of the nth power of $x \pm y$, when he doesn't know what is meant by solving $s = vt$ for t, or what to do to the equation $vp = v'p'$ to get $\frac{v}{v'} = \frac{p'}{p}$. And right here is an appropriate place to protest against the effort to teach algebra pupils physics, without the aid of the experiments which physics pupils find indispensable to an understanding of the topics studied. Unless, for example, you can find time to illustrate the principle of moments by an experiment, fully explained and understood, better let them solve the equation, $FD = Rd$ without any attempt to explain its physical meaning. Also, if the author misuses physical terms as power and weight, for effort and resistance; or pressure for force, cut out his physics entirely. It is better for the pupil not to know so much physics than to know so much that isn't so.

Again, an unnecessary amount of time is often spent on H. C. F. and L. C. M. What if a pupil doesn't find and cancel out every common factor? Better see that he cancels out factors that are obvious, and that he knows what he is doing, than teach him to find the H. C. F. of

x^6-y^6 and $x^7+x^6y+x^5y^2+x^4y^3+x^3y^4+x^2y^5+xy^6+y^7$.

He will never need to know that H. C. F. unless you make a problem on purpose, and it will not be a concrete problem. After you have taught him that, he will still take the equation (1) $x/10 = 3/10$, and clear it of fractions thus: (2) $10x = 30$, instead of (3) $x = 3$. Is there one pupil in a hundred who, after a year of algebra, can tell you that he got equation (2) by multiplying each member of (1) by 100? Or that you got (3) by multiplying each member by 10? Is there one in a thousand who will tell you that, and justify it by quoting the proper axiom? How many will tell you that to find the value of x in the equation $2x = 10$, you divide each member by 2? Still fewer will say that you multiply each member of $x/2 = 10$ by 2; and if you tell them to multiply each member by 2, most likely the result, if not absolutely incorrect, will be $2x/2 = 20$. The pupil may say that you find the value of x, or that you clear of fractions, or multiply the 10 by 2, or transpose the 2 to the other side to get all the knowns on that side. The nearest right he is likely to get is to multiply the equation by 2, instead of multiply each member by 2, thus making it a mere mechanical operation instead of a step in a process of reasoning. Why have you a right to multiply an equation by 2 when you mark him wrong for multiplying a single fraction by 2? Would it not pay to make that point clear, even if you never get to quadratics at all?

So long as the vast majority of high school seniors do not know that there are just four things that you can do to an equation (aside from performing indicated operations and substituting equals for equals), viz.: Add the same number to each member (not to *both* members, as some careless authors say); subtract the same number from each member; multiply each member by the same number; and divide each by the same number, so long should it be a crime to let a pupil use, or hear, or see such expressions as clear of fractions, transpose, get x out from under the radical, or any other expression that substitutes a mechanical operation for an operation justified by an axiom. I had almost included simplify in this list, for it often covers and fosters much ignorance. We sometimes need to use it, to show why we perform some operation; but it should be made clear that if what we are simplifying is an equation, we are doing one of the above things to it; if it is a fraction, we have multiplied both numerator and denominator by the same number, and therefore have

not changed its value. On the other hand, we do change the values of members of an equation; and when many pupils habitually write $2x = 6 = x = 3$, we need to spend more time on fundamentals even if we must cover less ground.

We do not need definitions of addition, subtraction, or multiplication; but the definition of division has so many uses that it ought to be carefully taught. One use is that it is the best way to show the relation of the units in divisor, dividend, and quotient; and a clear idea of the units is often the key to the pupil's whole difficulty. Thus, if he thinks, division is the process of finding one of two factors (called the quotient), when the other factor (divisor) and the product (dividend) are given, he will know that 10 lb. ÷ 2 = 5 lb., while the ratio of 10 lb. to 2 lb. is the abstract number 5. Also, 10 ft. ÷ 5 ft. /sec. naturally = 2 sec. $(10f \div \frac{5f}{s} = 2s)$.

A source of much vagueness, and consequent confusion and difficulty, is the practise, instigated by some authors, and abetted by some teachers, of letting $x =$ the distance (instead of the number of miles or feet), or the cost (instead of the number of dollars or cents), and so on. If the pupil does not think miles or dollars till he reaches the answer, he will have no reason for his answer. Indeed, he cannot think without thinking in some unit, and that is the very reason why, in so many cases, he does not think at all, but simply gives up, when confronted with a concrete problem. The pupil can never do concrete problems, that is, he can never independently make any use of algebra, unless he somehow learns instantly to think of x as a number of miles, or whatever the units may be. And the best way, in my judgment the only way, to learn to think, is to cultivate the habit of saying what you mean. In the course of the year, the cultivation of this habit will save more time than it costs; and in any case an algebra course that has not taught this habit is a failure.

FAKE GEOLOGISTS.

It sometimes happens that men who have no connection with the Geological Survey of the Interior Department pass themselves off as members of that organization, either to invest themselves with unmerited importance or to obtain information or facilities that might otherwise be denied them. It should be generally known to the public that each member of the Federal Geological Survey carries an identification card signed by the Secretary of the Interior and the Director of the Survey, and he is always ready to produce this card on request, should there be any question of his official standing.

SOCIALIZING BOTANY.

By H. N. Kauffman,
Flathead County High School, Kalispell, Mont.

In presenting a subject to students, each real teacher has definite and well formulated aims or goals toward which he strives. These aims will differ as teachers' opinions vary in regard to the most important benefits which may be derived from that particular subject.

In teaching botany, some will place a great deal of emphasis upon the disciplinary value acquired by close observation in laboratory exercises; some will place stress upon the cultural phase, revealing itself in an increased appreciation of the activities of plant life; while others believe that the greatest emphasis should be placed upon the utilitarian or economic factor. All of us will admit that the best test of the value of a subject is its contribution to citizenship. The greatest emphasis then should be placed upon those factors which contribute most toward good citizenship.

In a well balanced course, all of the above factors may be brought into play successfully. However, I believe that many teachers of botany have lost sight of another important element in plant study—the social factor. By socializing botany, I mean that the subject should be so presented that it arouses an active interest in the minds of the class concerning groups of people in other sections of the world. Friendship and peace accompany interest and cooperation among men; distrust and war accompany disinterest and noncommunion. Many provincial and national prejudices are only imaginary walls arising from ignorance and disinterest concerning other groups of people. In teaching grade, high school and college people, this social factor must play an important part in the formation of good citizenship.

With this social element in view, we have worked out two methods of procedure by which results have been very satisfactory: First, my two botany classes have been organized into "nature study clubs." They have their own officers and meet each Friday afternoon at regular class time. I reserve the privilege of being one of the members of the program committee. The programs of some meetings are composed of talks and papers by members of the club, while others are composed of talks and illustrated lectures by business and professional men. In nearly all communities people may be found who have lived in other parts of the world, and they are glad to give talks concern-

ing the plant and animal life of that particular place. At one meeting, a man who had spent several years in Australia gave a very interesting talk concerning the life of that country; one member of the faculty who had lived in Porto Rico gave an instructive talk concerning the life of that island; another member of the faculty who has been in England aroused the interest of the club by a talk concerning the life of that country; again, one of the boys who had been down at the border for several months gave a very interesting talk in regard to the plant and animal life of that place; furthermore, keen interest was aroused by illustrated lectures concerning our national parks and our bird life. In the near future we expect to hear talks on Argentina, Chili, Alaska, China, and the Philippines.

The following are representative subjects upon which papers and talks were given by the members of the club: rice, cocoa, coffee, sugar, tapioca, banana growing, cotton and cottonseed products, corn products, wheat products, hemp, jute, sisal, flax, rubber production, etc. The content of the program is varied from meeting to meeting. After each paper or talk a free discussion is encouraged.

The second method by which the class has been aided to a lively interest in the social phase of botany has been accomplished by the organization of honorary clubs in plant collection. At the beginning of the semester, I suggested to the class the opportunity of becoming members of three honorary clubs, *viz.*, the Montana State High School Club of Plant Study; The American High School Club of Plant Study; and the International High School Club of Plant Study. The requirements of each club are outlined below. These are only tentative requirements and may be modified as need arises.

We are not doing extensive herbarium work, but we are obtaining interest in local plants by means of the home garden projects, and the collection of plants made by the pupil in order that he may exchange with another school. Some of the pupils are already sure of meeting the requirements of the State and American clubs. Because of the uncertainty of mail, we cannot hope to do much with the International Club until after the war.

By the two methods outlined above, the class shows a new interest in the whole field of botany; and indirectly these organizations have increased their interest concerning other groups of people.

This club work need not be confined to botany alone. Any class whose pupils are old enough to take an active interest in

this kind of work may cooperate in this organization. The hearty response which I have received from teachers of botany has led me to believe that the organization presented below can be conducted to mutual advantage. The following is a copy of a letter which I mailed March 27, 1917, to the biology teachers of this state and to a few schools of other states:

Dear Instructor:

Are you interested in a plan of cooperation among the botany students of this state? I am suggesting a plan by which the interest in botany may be increased.

Not one of us will deny that the best test of the value of a subject is its contribution to citizenship. To make this subject count for good citizenship, I believe that we must not only emphasize the utilitarian and cultural elements, but also the social factor. To aid in socializing botany I suggest a plan of sympathetic and active cooperation among the botany students of this state.

I have invited my pupils to work toward four cooperative high school clubs: *viz.*, The Flathead High School Club of Plant Study, The Montana State High School Club of Plant Study, The American High School Club of Plant Study, and the International High School Club of Plant Research. Each is required to become a member of the first club, while the other three are optional and honorary clubs.

The enthusiasm and interest shown by my classes in this work has led me to submit the plan to the botany teachers of this state. This is not an extra burden for the teacher since the work is optional and is performed entirely by the student. I believe that it will work to mutual advantage if the botany teachers will at least propose a State High School Club to their pupils. We might then agree upon some certificate of merit to be presented to those who become members of this club. I do not know that any such clubs as I suggest are in existence only in so far as we have worked out a scheme here.

RULES.

1. Flathead High School Club of Plant Study—required of all. (a) Each must collect and classify at least fifteen plants from this basin. (b) At least three organs of each plant must be obtained. The organs include root, stem, leaf and flower. The fruit may be substituted in place of the flower.

2. Montana High School Club of Plant Study—honorary. (a) Each must collect and write an essay concerning ten plants from other sections of the state. (b) At least three organs of each plant must be obtained. (c) Students are asked to obtain the assistance of their friends and other schools to aid them in this collection.

3. American High School Club of Plant Study—honorary. (a) To become a member, each must collect and write an essay concerning plants obtained from six different states, including Montana. (b) At least two organs of each plant must be obtained. (c) Students are invited to obtain the assistance of their friends, botany classes of other states, etc., to obtain these plants.

4. International High School Club of Plant Study—honorary. (a) To become a member, each must obtain and write an essay concerning three plants obtained from foreign countries. (b) At least two organs of the plant must be obtained. (c) Students are invited to cooperate with friends, foreign schools, consuls, missions, etc., to obtain these plants.

If your pupils are interested in such a plan of cooperation, I will be glad to have you advise me. Then I will mail to each school which enters this work a list of all the other schools entering. This list will be of particular advantage to the students who may wish to exchange plants.

Hoping that I may receive an early reply from you, I am

Yours very truly,

H. N. KAUFFMAN.

PREPARATION OF TEACHERS FOR NATURE STUDY AND ELEMENTARY AGRICULTURE BY THE NORMAL SCHOOLS.

By Elliot R. Downing, Ph. D.,
School of Education, University of Chicago.

Some months ago a questionnaire was sent out to the normal schools of the United States asking, primarily, for information regarding the nature-study and agriculture courses offered to normal school students, and also concerning the nature-study or elementary science work given in the practice schools; incidentally, the questionnaire also called for data in regard to the courses in botany and zoology offered normal school students. The tabulation below presents the data thus obtained. The list of schools and principals given in the Educational Directory of the U. S. Bureau of Education (Bulletin No. 43, 1915) was used as the mailing list, and the customary self-addressed stamped envelope was enclosed in each letter of inquiry to facilitate reply. About fifty-one per cent of the schools sent replies, though many were so incomplete as to make them useless for purposes of comparison. It was deemed advisable to send a second letter to such schools as did not respond to the first, and a number of additional replies were received. Out of a total of 245 public and 40 private normal schools, fairly complete replies have been received from 145 public and 17 private schools. In addition, in the table below there are data from three universities that have been particularly active in nature-study work. Since some time elapsed between the two sets of letters of inquiry, the data given are not all for the same school year, but they will give a fair idea of present conditions.

Out of a total of 165 schools whose replies are tabulated, there are 157 schools that maintain a practice or observation school; five of the eight not so doing are private schools. Nature study is given in 128 out of the 157 practice schools (81.4 per cent) and 95 of them (60.2 per cent) give it in all the grades they maintain. This nature study is taught in some schools only once a week, in others two or more times a week, the average being about three times per week (2.93). It is difficult to strike an average when replies are given in such variable terms as two to five times per week; this was done by using the two times for one school reporting thus, the five for the next encountered in going down the list, and so on to the end. The course followed in the grades is systematized in 60 schools (38 per cent of all)

and is definitely outlined in 44 (28 per cent). These are conservative figures. Such indefinite statements as "the course is systematized by following seasonal changes," "by following the changing interests of the child," etc., do not entitle to a place in the group of schools with systematized courses. The outline, too, must be a detailed and definite outline, prescribing in exact terms the work expected from each grade in order that the school be reported as having an outline.

There are 114 schools out of 165 (69 per cent) that report one or more courses in nature study offered to prospective teachers in preparation for teaching elementary science in the grades, and 110 of them give the length of the course or courses. The extremes for the latter are 5 and 108 weeks. The attempt has been made to express the length of these courses in a common unit, a week of five school days with a class exercise each day. In a few cases the statement of facts in the replies was indefinite or ambiguous, so that it is impossible to be certain the figures given in the table are quite correct; some error of judgment is likely, therefore, in these data. It is not important enough, however, to vitiate the resulting average of 23.9 weeks' possible preparation in nature study. Courses in botany, zoology, physics, etc., offered normal school students are not considered as nature-study courses in this article; only such courses are included here as are distinct nature-study courses, designed to directly prepare teachers for the elementary science instruction in the grades. This statement is made merely to define the meaning of the phrase "the nature-study course" as here used. It is not made to express an opinion on the value of botany, zoology and such systematic science courses as proper preparation for grade instruction in elementary science. Such courses are offered the prospective teacher in not a few of the schools and they are listed by the science instructor as a reply to my question, "Does your school offer the normal school students a course in nature study?" Evidently they are regarded as adequate preparation by some normal school science teachers, though not by the majority.

A nature-study course is required of all students by 74 schools (44.9 per cent); of some students by 10 schools (6 per cent). The average length of the course in those schools that require it of all students and that also report the length of the course is 23.5 weeks. The time given to "methods" as distinct from subject matter in the nature-study course for prospective teach-

ers varies from nothing to the entire time of the course, with an average of 8.4 weeks in the 59 schools that report definitely on this item (51.8 per cent of all that give a nature-study course).

Courses in elementary agriculture are given to prospective teachers in many schools. In some cases these are given in addition to nature-study courses, in others in place of the latter. In the latter case it evidently is the expectation that these agriculture courses will serve the teacher better in her nature work in the grades than nature-study courses. Courses in elementary agriculture for the grade teacher are offered in 100 schools (60.6 per cent). In 24 schools the elementary agriculture is given, but no nature study, in the rest of the 100 both elementary agriculture and nature study are given. The average length of the course (or courses) in agriculture is 22.7 weeks, and the extremes are 2 and 108 weeks. Out of the 100 schools offering agriculture, 41 require it and 22 of these have a course in nature study that is also required of all students, so that 13.3 per cent of all the 165 schools require both nature study and elementary agriculture courses for graduation.

Eighty-three of these 162 normal schools (51.2 per cent) give courses in botany; 36 offer one course, 17 offer two, 16 offer three, 8 offer four, 2 offer five, 1 offers six and 3 offer seven, an average of 2.3 courses per institution that gives the subject at all.

There are 86 schools offering zoology courses as follows: 31 offer one course, 20 offer two, 15 offer three, 3 offer four, 5 offer five, 1 offers six, and 1 offers nine courses, an average of 2.1 courses per school.

Biology courses are offered by thirteen schools; the biology is given in addition to botany in three, in addition to both botany and zoology in one.

The tabulation of data is shown on the next eight pages. For the particular school read across to the odd numbered pages.

State	Name of School	Summer Session	Entrance Requirements. H. S. Grad.	3	2	1	8th Gr.
Ala.	1. Daphne Normal School, Daphne	*					7th
	2. State Normal School, Florence	*				*	
	3. Jacksonville St. Normal	*				*	
Ariz.	4. State Normal School, Tempe		*	*	*	*	*
Ark.	5. State Normal School, Conway	*	Must be 16 yrs.				*
Cal.	6. State Normal School, Chico		*				
	7. State Normal School, Fresno	*	*				
	8. State Normal, Los Angeles		*				
	9. State Normal, San Diego		*				
	10. State Normal, San Francisco	*	*				
	11. State Normal, San Jose		*				
	12. State Normal of Manual Arts and Home Economics, Santa Barbara	*	*				
Colo.	13. Denver Normal and Prep. School (Pr.)	*	Ability to do work				
	14. State Normal School, Gunnison	*	*				
Conn.	15. City Normal, Bridgeport	*	*				
	16. State Normal, Danbury	*	*	Successful teaching.			
	17. State Normal Training School, Willimantic		*	Not enforced			
D. C.	18. Jas. Ormond Wilson Normal		*				
	19. Myrtilla Miner Normal School		*				
Ga.	20. State Normal School, Athens						*
Idaho	21. State Normal, Albion	*	*	*			*
	22. State Normal, Lewiston	*	*				
Ill.	23. Eastern Ill. State Normal, Charleston	*	*		*		*
	24. Ill. State Normal Univ., Normal	*	*		*		*
	25. Northern Ill. State Normal, DeKalb	*	*	*			*
	26. Southern Ill. State Normal Univ., Carbondale	*	*		*	*	*
			Certificate of good moral character.				
	27. University of Chicago, The School of Education (Pr.)	*	*				
	28. Western Ill. State Normal, Macomb	*	*	*	*	*	*
Ind.	29. Central Normal College (Pr.)	*					
	30. Ft. Wayne Normal Training School		*				
	31. Normal Training School, Indianapolis		*				
	32. Teacher's College, Indianapolis (Pr.)	*	*				
	33. Tristate College, Angola (Pr.)	*	*				
Ia.	34. Western Normal College	*	*	*	*	*	*
Kan.	35. State Normal School, Emporia	*	*				*
	36. Fort Hays, Kansas Normal School, Hays	*	*				*
Ky.	37. Chandler Normal, Lexington (Pr.)						*
	38. Kentucky Normal College (Pr.)	*					*
	39. Western State Normal	*					*
La.	40. State Normal, Natchitoches	*	*				*
			Health certificate Men must be 16 Women must be 15				
	41. New Orleans Normal School		*	*			
Me.	42. Eastern Maine Institute (Pr.)						*
	43. Eastern State Normal School, Castine	*					
	44. Washington State Normal	*	*				
	45. Western State Normal		*				
Md.	46. Frostberg State Normal School		*				
	47. Teachers Training School, Baltimore		*				
	48. Training School for Colored Teachers		*				
Mass.	49. Boston Normal		*				
	50. Bridgewater State Normal		*				
	51. State Normal, Fitchburg		*	Certificate of good character			
			Men must be 17 Women must be 16				
	52. Framingham Normal		*				
	53. Hyannis Normal School	*	*				
	54. State Normal, Lowell		*	Examination			
			Men must be 17 Women must be 16				
	55. State Normal, North Adams		*				
	56. State Normal, Salem		*				
	57. State Normal, Westfield		*				
	58. State Normal, Worcester		*				
Mich.	59. Central State Normal, Mount Pleasant	*	*				*
	60. Mich. State Normal College, Ypsilanti	*	*				

* Indicates affirmative reply to questions.

Observation School	No. of Grades	No. of Teachers	Nature Study in what Grades	Days per Week	Is Course Systematized?	Outline?	Length of Course in N. S. or El. Sc. for Normal Students	No. in Course when last given	Required of
*	7	2							
*	7	7	All	Every	Yes	Yes	108 weeks		All
*	7	4	1–4		No	In making	36 weeks	36	All
*	8	9	2–7	1 or 2	Yes	Yes	40 weeks	63	All
*						Yes	Yes		
*	8	4	1–8	3	Yes	Yes	20 weeks		All
*	8	7	6–8	1			18 weeks	270	All
*	10		All	2 to 5			8 courses	600	Elec.
*	8	7	3–8	2	Yes	8th Gr.	10 weeks		All
*	8	25	5–8	3				65	
*	8	11	4–7	5			12 weeks	150	All
*	4–12								
							6–14–19		All
*							12 weeks	26	
*	5	5	1–5	1			12 weeks	41	All
*	8	25	1–8	2 to 3	Yes	Yes	60 weeks	208	All
*	8	18	1–7				20 weeks		All
*	Kg–4	8	Kg–4		Yes	Yes	24 weeks		All
*	1–4	4	1–4	5			24 weeks	121	All
*	8	6	1–8	2	Yes				
*	8	9	1–5	2–3	Yes	State	12 weeks	18	Life Dip.
*	8		1–8	4	Yes		9 weeks	20	All
*	8	8	1–8	2			24 weeks	75	All
*	1–12	13	1–8	5	Yes	Yes	12–36	140	All
*	1–8	10	1–8	2 to 5	Yes	Yes	39 weeks	160	All
*	8	4	1–8						
*	Kg–11		1–7	2 to 5	Yes	Yes	42 weeks (4 courses)	161	Kg. and Supt.
*	1–8	7	1–8	5	Yes	Yes	12 weeks	100	All
*	1–6	8	1–6	5			20 weeks	20	All
*	1–6	18	1–6	5	Yes	Yes	7 weeks	62	All
*	8	10	1–8	5			72 weeks	185	
*	5	3	1–4						
							18 weeks		
*	Kg.–8	5	1–3	5			18 weeks	146	Spl. R'rls and El.
*	1–12	11	1–8	2 to 5	Yes	Seasonal	50 weeks	30	
*	8	7	1–8	5					
							36 weeks	29	
*	8	9	1–8	2			10 weeks	189	All
*	10	10					*		
*	8	12	1–8	2			36 weeks		All
*	9	2	1–9				5 weeks	17	All
*	8	5	1–8						
*	9	5	1–9	5					
*	9	16	1–9				30 weeks	120	All
*	8	4	8th	1					
*	8	18	1–8	1 hr.	Yes	Yes	54 weeks	300	All
*	8	12	1–6	2	Yes	Yes	8 weeks		All
*	8	23	1–8	5	Yes	Yes	8 weeks	62	All
*	10	13	Kg–7						All
*	8								
*	9	9	1–9	2			50 weeks	154	All
*	9	7	1–9		Yes	Yes	40 weeks		All
*	9	18					*		
	9	20	1–9 Sch. Garden				57 weeks	80	All
*	8	9	1–8	1–2	Yes		26 weeks	138	All
*	Primary and Kinderg.						*		
*	9	16	2–6	1			36 weeks		All
*	8	9	1–4	1–2			12 weeks	45	Primary
*	13	35	Kg–8	3–5	Yes	Yes	12 weeks	81	Kinder. and Pri.

State	Name of School	Time given to Methods	Length of Course in El. Agric. for Normal Students	No. in Course when last given
Ala.	1. Daphne Normal School, Daphne			
	2. State Normal School, Florence		36 weeks	50
	3. Jacksonville State Normal	12 weeks	36 weeks	30
Ariz.	4. State Normal School, Tempe	10 weeks	40 weeks	82
Ark.	5. State Normal School, Conway	Greater part	6 courses	
Cal.	6. State Normal School, Chico	10 weeks	Yes	
	7. State Normal School, Fresno		18 weeks	270
	8. State Normal, Los Angeles		12 weeks	80
	9. State Normal, San Diego	1 week	40 weeks	15
	10. State Normal, San Francisco			
	11. State Normal, San Jose	12 weeks	12 weeks	24
	12. State Normal of Manual Arts and Home Economics, Santa Barbara			
Colo.	13. Denver Normal and Prep. School (Pr.)			19
	14. State Normal School, Gunnison		12 weeks	
Conn.	15. City Normal, Bridgeport	4 weeks		
	16. State Normal, Danbury		10 weeks	100
	17. State Normal Training School, Willimantic		20 weeks	20
D. C.	18. Jas. Ormond Wilson Normal	3 weeks	12 weeks	
	19. Myrtilla Miner Normal School	4 weeks	*	16
Ga.	20. State Normal School, Athens		36 weeks	140
Idaho	21. State Normal, Albion	All	18 weeks	27
		12 weeks req. of all rural		
	22. State Normal, Lewiston	9 weeks	36 weeks	45
Ill.	23. Eastern Illinois State Normal, Charleston	6 weeks	36 weeks	16
	24. Illinois State Normal University, Normal	6 weeks	48 weeks	23
	25. Northern Illinois State Normal, DeKalb	2-3 wks.	24 weeks	20
	26. Southern Illinois State Normal Univ., Carbondale		20 courses	
	27. University of Chicago, The School of Education (Pr.)	6 weeks	12 weeks	28
	28. Western Illinois State Normal, Macomb	12 weeks	12 weeks	19
Ind.	29. Central Normal College (Pr.)		48 weeks	60
	30. Ft. Wayne Normal Training School	10 weeks		
	31. Normal Training School, Indianapolis	2 weeks		
	32. Teacher's College, Indianapolis (Pr.)			
	33. Tristate College, Angola (Pr.)			
Ia.	34. Western Normal College (Pr.)	Little	12 weeks	
Kan.	35. State Normal School, Emporia		36 weeks	100
	36. Fort Hays, Kansas Normal School, Hays	5 weeks	Agr. course of 4	yrs.
Ky.	37. Chandler Normal, Lexington (Pr.)			
	38. Kentucky Normal College (Pr.)	6 weeks	20 weeks	18
	39. Western State Normal		40 weeks	89
La.	40. State Normal, Natchitoches			
	41. New Orleans Normal School	9 weeks		
Me.	42. Eastern Maine Institute (Pr.)		36 weeks	14
	43. Eastern State Normal School, Castine		12 weeks	
	44. Washington State Normal		12 weeks	27
	45. Western State Normal		12 weeks	120
Md.	46. Frostberg State Normal School		21 weeks	80
	47. Teachers Training School, Baltimore	40 weeks	40 weeks	
	48. Training School for Colored Teachers			
Mass.	49. Boston Normal	2 weeks		
	50. Bridgewater State Normal			
	51. State Normal, Fitchburg			
	52. Framingham Normal	12 weeks	38 weeks	72
	53. Hyannis Normal School			
	54. State Normal, Lowell			
	55. State Normal, North Adams		19 weeks	80
	56. State Normal, Salem	12 weeks		
	57. State Normal, Westfield			
	58. State Normal, Worcester			
Mich.	59. Central State Normal, Mount Pleasant		24 weeks	54
	60. Mich. State Normal College, Ypsilanti	3 weeks	12 weeks	32

Required of	Number of Courses in Botany	Number of Courses in Zoology	Does the school prepare for H. S. Teaching?	How?	No. of Grads. Teaching in H. S.?	Which is what % of Grads.	What % of these teach Science	No. of Instr. in Sci. Dept.
						50%	50%	1
All	Biology-2		No					3
All								3
All	1	1	No		10		20%	1
	1	3						2
			No			3%	10%	3
								2
								5
Elec.	1	Biology-1	No					3
			No					2
Elec.		1	No		0			2
All	1	1						2
	2	2	No		1			2
			No		1			1
All	1		No					3
All 2 yr.			No					1
All								2
All	1	1	No		3			1
All	3	Biology-3						4
					17	20%		3
Rural sch. teachers	2	2	M'n. Tr.,Phys. Ed., Home Ec.					3
Rural Sch. teachers	3	6	No			⅕%		3
	4	5	Yes	Courses Practice Tchg.	40-60 yrly.	45%	13%	3
	1	2	No					3
	4	2	Yes					7
			Yes	Special Courses and Degree				7
	2	2				30-40%		3
			No					1
			No					1
			No					1
			No					3
	2	2	Yes	One course specially organized		50%	30%	3
All	1	1	No					2
	7	5	Yes	Practice Teaching		50%	5-7%	5
	3	3,Biol. 3	Yes	College Subjects				4
	Biology 3		No					1
	3	3	No			10%	Most	3
All grads.	2	2	Yes	Major and Minor Seq.	15	33%		1
			No					
	1		No					3
	Biology 3		No		2			3
	1							1
All	1	1	No					2
All except Man. Tr.			No					3
All	1	1	No					1
			No					1
			No					1
	2	2	No					1
All								1
			No					2
All								2
								1
All	1	1				10%		1
			No					1
			Commercial					2
			No					1
	3	4	Yes		79	6-10%		2
	7	6	Yes	Acad. wk. prof. courses prac. teaching	60	7%	Small	9

State		Name of School	Summer Session	Entrance Requirements. H. S. Grad.	3	2	1	8th Gr.
	61.	Northern State Normal, Marquette	*	*				*
	62.	Western State Normal, Kalamazoo	*	*				*
Minn.	63.	Lutheran Normal School (Pr.)			*			
	64.	State Normal, Duluth	*	*				*
	65.	State Normal, Mankato	*	*				
	66.	State Normal, Moosehead	*					*
	67.	State Normal, St. Cloud	*	*				*
	68.	State Normal, Winona	*	*				
Miss.	69.	State Normal, Hattiesburg	*					
	70.	Ind. Agr. College for Negroes	*	*	*	*	*	*
Mo.	71.	Harris Teachers College	*	*				
	72.	State Normal, Cape Girardeau	*					
	73.	State Normal, Kirksville	*	*				
	74.	State Normal, Springfield	*	*				
	75.	State Normal, Warrensburg	*	*				
Mont.	76.	State Normal, Dillon	*	*				
Neb.	77.	Peru State Normal School	*	*				
	78.	Wayne State Normal	*	*				
N. Hamp.	79.	State Normal, Keene		Successful teaching				
N. J.	80.	Jersey City Teachers Training School						
	81.	Newark State Normal						
	82.	State Normal, Upper Montclair		*				
N. M.	83.	Normal University	*	*				
	84.	State Normal, Silver City	*	*				
N. Y.	85.	State Normal, Brockport		*				
	86.	Brooklyn Training School		*				
	87.	Buffalo State Normal						
	88.	Cornell University, College of Agriculture	*	*				
	89.	Cortland Normal Training School						
	90.	Fredonia Normal School		*				
	91.	Geneseo State Normal	*	* or tchg. exp.				
	92.	N. Y. Training School for Teacersh		*				
	93.	Oneonta State Normal School	*	*				
	94.	Oswego State Normal School		* and by appointment				
	95.	Plattsburgh State Normal School		*				
	96.	Potsdam State Normal School	*	*				
	97.	Syracuse Training School for Teachers		*				
	98.	Teachers College, Columbia Univ. (Pr.)	*	B. S. degree				
	99.	Teachers Training School		*				
	100.	Training School for Teachers, Yonkers		*				
N. C.	101.	Albemarle Ind. and Nor. Inst. (Pr.)						
	102.	East Carolina Teachers Training School, Greenville	*	*				*
	103.	Indian Normal College, Pembroke						
	104.	Normal and College Institute (Pr.)				*		
	105.	St. Augustine School, Colored (Pr.)						*
	106.	State Normal of N. C.	*					6th
	107.	State Normal and Ind. College, Greensboro	*	*				
N. D.	108.	State Normal, Mayville	*					
	109.	State Normal, Minot	*	*				
	110.	State Normal, Valley City	*	*				
O.	111.	Dayton Normal School		*				
	112.	Kent State Normal	*	*	*			
	113.	Perkins Normal, Akron		*				
Okla.	114.	Central State Normal	*		*			*
	115.	East Central State Normal	*					*
	116.	Northeastern State Normal	*					*
	117.	Northwestern State Normal, Alva	*					*
	118.	Southeastern State Normal, Durant	*					*
Ore.	119.	Oregon Normal School, Monmouth	*		*			
Penn.	120.	Cumberland Valley State Normal	*					*
	121.	Central State Normal School, Lock Haven		*				
	122.	Edinboro State Normal						
	123.	Erie Normal		*				
	124.	Keystone State Normal						*
	125.	Millesville State Normal	*	*				
	126.	Normal Training School for Girls		*				
	127.	Philadelphia Normal School for Girls		*				
	128.	School of Pedagogy, Philadelphia		*				
	129.	Southwestern State Normal		*				*
	130.	Teachers Training School, Harrisburg		*				
R. I.	131.	Rhode Island Normal School		*				
S. C.	132.	State Normal, Ind. and Agr.	*					
	133.	Winthrop Normal and Ind. College	*	*	*			
S. D.	134.	Lutheran Normal School (Pr.)	*	*				*

Observation School	No. of Grades	No. of Teachers	Nature Study in what Grades	Days per Week	Is Course Systematized?	Outline?	Length of Course in N. S. or El. Sc. for Normal Students	No. in Course when last given	Required of
*	8	10	Kg–8	2			12 weeks	55	All
*	9	10	Kg–8	3			12 weeks	25	All
*	6	1	1–6	3			18 weeks	40	All
*	8	4	1–8	3–4	Yes	Yes	12 weeks	80	All
*	8	10	1–6 & 8	2–3	Yes	Yes	18 weeks	69	All
*	Kg–8	8	*				12 weeks	45	
*	8	9	1–8	2			12 weeks	80	All
*	Kg–8	15	Kg–8	5	Yes		12 weeks	25	
*									
*	4	3	1–4	2			12 weeks		All
*	8	22	1–8	1	Yes	Yes	40 weeks	65	All
*	Kg–10	6	Kg–10	2–5			12 weeks	48	
*	10	10	1–10	5	Yes	Yes		200	
*	10	7	1–6		Yes	Yes	24 weeks	150	Primary
*	Kg–10	8	1–6	5	Yes	Yes	12 weeks	31	Rural
*	8	23	1–4	1			8 weeks	24	All
*	10	10	1–8	2			18 weeks	45	Kinder.
*	Kg–8	5	Kg–8	2	Yes	Yes	18 weeks	22	Gr. Tch.
*	8	23	1–8	1					All
*	8	30	1–8	1	Yes	Yes	40 weeks	95	All
*	8	40	1–8	2	Yes		30 weeks	320	All
							24 weeks	200	
*	8	5	1–8	1–2					
*	8	5	4–8	4	Yes		18 weeks		
*	12	9	1–8	3	Yes	Yes	20 weeks	150	All
*	8	34	Kg–5	2	Yes		20 weeks	310	All
*	9	10	1–9	2		Yes	10 weeks	268	All
							21 weeks	s'vral hun	All
*	8	7	1–8	2			20 weeks	150	All
*	Kg–8	10	Kg–6	3	Yes		20 weeks		All
*	8	13	1–6	2	Yes	Yes	20 weeks		All
*	6	17	1–5	3		Yes	20 weeks	183	All
*	8	20	1–8	2	Yes	Yes	18 weeks	197	All
*	Kg–6 H. S.						20 weeks	50	
*	8		1–8	1	Yes	Yes	20 weeks	48	All
*	1–8	3	1–8	3	Yes	Yes	20 weeks	50	
*	8	13	1–8	1			20 weeks	19	All
*	6	20	1–6	1	Yes		30 weeks		
*	Kg–8	17	Kg–8	3			19 weeks	36	All
Use city schools							19 weeks	30	All
*	6		1–6						
*	4	4							
*	10	4							
*	5		1–5	3					
*	4	3	1–3						
*	5	2	4–5	5			16 weeks	105	
*	12	13	1–8	2		In making			
*	8	9	1–8						
*	8	4					36 weeks	140	
*	8	8	1–8		Yes	Yes			
*	8	4	1–8				40 weeks	80	
*	8	6	1–8	5	Yes	In making	12 weeks	60	
*	8	4	1–4	5			8 weeks	12	
*	8	4					12 weeks	20	
*	8	3	3–8	2			12 weeks	18	
*	8	4	1–8	5					
*	8	6	Kg–8	5	Yes		One Sci. course of all		
*	8	4	3–8	2	Yes				
*	8	5	1–4		Yes				
*	9	2	1–5	5			40 weeks	75	All
*	9	7	1–9	1	Yes		12 weeks	92	All
*	8	7	1–2	5					
Use city schools			1–8	3	Yes	Yes	38 weeks	24	All
*	8	5					13 weeks	115	All
*	11	8	1–11						
*	5	9	1–5	2	Yes	Yes	36 weeks	24	All
*	Kg–8	25		2	Yes	Yes	6 weeks		All
*			5–8	2	Yes	Yes	36 weeks		All
*	Kg–8	3	Kg–8				20 weeks	130	All
*	3	2	1–3	5					
*	8	14	1–8		Yes	Yes	8 weeks	58	All
*	3		1–3	2					All
*	10	10	1–10	1	Yes	Yes			
	8	1	3–6	5					

State	Name of School	Time given to Methods	Length of Course in El. Agric. for Normal Students	No. in Course when last given
	61. Northern State Normal, Marquette		12 weeks	
	62. Western State Normal, Kalamazoo		36 weeks	35
Minn.	63. Lutheran Normal School (Pr.)		18 weeks	28
	64. State Normal, Duluth			
	65. State Normal, Mankato	6 weeks	20 weeks	20
	66. State Normal, Moosehead	4 weeks	12 weeks	43
	67. State Normal, St. Cloud	6 weeks	12 weeks	
	68. State Normal, Winona		12 weeks	20
Miss.	69. State Normal, Hattiesburg			
	70. Ind. Ag. College for Negroes	6 weeks	12 weeks	
Mo.	71. Harris Teachers College	10 weeks		
	72. State Normal, Cape Girardeau	3 weeks	38 weeks	40
	73. State Normal, Kirksville		12 weeks	36
	74. State Normal, Springfield		24 weeks	60
	75. State Normal, Warrensburg	Little	24 weeks	75
Mont.	76. State Normal, Dillon			
Neb.	77. Peru State Normal School	4 weeks	18 weeks	29
	78. Wayne State Normal	3 weeks	18 weeks	95
N. Ham.	79. State Normal, Keene			
N. J.	80. Jersey City Teachers Training School	20 weeks		
	81. Newark State Normal	10 weeks	18 weeks	210
	82. State Normal, Upper Montclair			
N. M.	83. Normal University		18 weeks	50
	84. State Normal, Silver City	4 weeks	18 weeks	60
N. Y.	85. State Normal, Brockport	5 weeks	40 weeks	15
	86. Brooklyn Training School			
	87. Buffalo State Normal			
	88. Cornell University, College of Agriculture			
	89. Cortland Normal Training School	10 weeks		
	90. Fredonia Normal School			
	91. Geneseo State Normal	5 weeks		
	92. N. Y. Training School for Teachers			
	93. Oneonta State Normal School			
	94. Oswego State Normal School			
	95. Plattsburgh State Normal School	10 weeks		
	96. Potsdam State Normal School			
	97. Syracuse Training School for Teachers	Most		
	98. Teachers College, Columbia University (Pr.)	15 weeks		
	99. Teachers Training School	8 weeks		
	100. Training School for Teachers, Yonkers	Most		
N. C.	101. Albemarle Ind. and Nor. Inst. (Pr.)			
	102. East Carolina Teachers Training School of Greenville		11 weeks	105
	103. Indian Normal College, Pembroke		*	
	104. Normal and College Institute (Pr.)		12 weeks	52
	105. St. Augustine School, Colored (Pr.)		12 weeks	32
	106. State Normal of N. C.		16 weeks	105
	107. State Normal and Industrial College, Greensboro		*	40
N. D.	108. State Normal, Mayville			
	109. State Normal, Minot		36 weeks	130
	110. State Normal, Valley City		36 weeks	160
O.	111. Dayton Normal School	8 weeks		
	112. Kent State Normal		12 weeks	260
	113. Perkins Normal, Akron			
Okla.	114. Central State Normal		12 weeks	125
	115. East Central State Normal		12 weeks	30
	116. Northeastern State Normal		12 weeks	40
	117. Northwestern State Normal, Alva		24 weeks	
	118. Southeastern State Normal, Durant		36 weeks	83
Ore.	119. Oregon Normal School, Monmouth		20 weeks	140
Penn.	120. Cumberland Valley State Normal		20 weeks	72
	121. Central State Normal School, Lock Haven	6 weeks	15 weeks	95
	122. Edinboro State Normal		25 weeks	93
	123. Erie Normal	All		
	124. Keystone State Normal	1/4	20 weeks	108
	125. Millesville State Normal		20 weeks	
	126. Normal Training School for Girls			
	127. Philadelphia Normal School for Girls	1/3		
	128. School of Pedagogy, Philadelphia	6 weeks		
	129. Southwestern State Normal	5 weeks	20 weeks	135
	130. Teachers Training School, Harrisburg			
R. I.	131. Rhode Island Normal School		2 weeks	58
S. C.	132. State Normal, Ind. and Agr.		20 weeks	
	133. Winthrop Normal and Industrial College		12 weeks	450
S. D.	134. Lutheran Normal School (Pr.)		6 weeks	16

Required of	Number of Courses in Botany	Number of Courses in Zoology	Does the school prepare for H. S. Teaching?	How?	No. of Grads. Teaching in H. S.?	Which is what % of Grads.	What % of these teach Science	No. of Instr. in Sci. Dept.
			No					2
Rural	6	5	Yes	Acad. work prac. teach.	64			4
All			No					3
	2	2	No					2
		3	No					3
	2	2	No					4
			No			37%		1
	2	2	No					1
	1	1	No					4
All	1	1	Industrial		*			1
	1	1	No		10			3
	5	9	Yes	Special dip.		25%		4
			Yes		300	40%	20%	4
	2	5	Yes	Maj.-Minor Seq. Pedagogy	180	40%	10%	4
	4	4	Yes	Specialization		40%	Small	4
	Biology 2		No					2
All	4	2	Yes		100	20%	25%	3
All	5	4	Yes	By requiring certain subjs.	30	25%	66%	4
All			No					2
	2	1						1
All	Biology							2
			No		6-8	1%		3
	1	1	No		16	10%		2
All	4	2	Yes	Major and Minor		33%	50%	4
Rural			No			57%		3
			No					6
			No					2
			Yes	Special courses	125	8%		
			No		6-8	2%		3
			No			10%		
			No			5%	All	2
			No		Few			5
			No					1
			In Com'l Subjects			60%		2
			No			10%		2
								2
	Given in Univ. Depts.		Yes					3
			No					1
			No					2
	1		No					3
All	Biology 2		No					1
All			No					1
	1		No					2
	1		No					2
			No					2
			Yes	Practice Tchg.	Many		Few	2
		1						1
	1							1
9th Gr.	1	1	No		Few			3
								1
All	2	1	Yes	Practice Tchg.				4
			No					2
All	3	3	Yes	Specialization	300	75%	4%	4
All	1	1	No			10%		1
All	4	3	No			33%	25%	2
All	3	3	No					3
All	3	3	No					3
			No			5%		1
	1	1	No			30%		3
All	2	1	No			15%		1
			No		Few			2
			No					1
All	1	1	No			8%	25%	1
Agricul.	1	1	No	Normal course	101	16%		4
			No	covers all H. S. sub.				1
	2	3	No					8
	Biology 1		No					1
	1	1	No			5%		4
								1
	2	1	No		3	1%		2
All		1				10%	All	4
Normal	3	2	Yes	Prof. Prep.		33%	Few	4
All	3							2

State	Name of School	Summer Session	Entrance Requirements. H. S. Grad.	3	2	1	8th Gr.
	135. Madison State Normal School	*	*				*
	136. Springfield State Normal	*					*
Tenn.	137. E. Tennessee State Normal	*	*				
	138. Geo. Peabody College (Pr.)	*	*				
	139. LeMoyne Normal Institute (Pr.)		*				
	140. Morristown Normal and Ind. College (Pr.)						*
	141. West Tennessee State Normal	*					*
Tex.	142. N. Texas State Normal	*				*	
	143. Sam Houston State Normal Institute	*			*		
	144. West Texas State Normal	*			*		
Utah	145. State School of Education (Univ. of Utah)		*				
Vt.	146. Castleton State Normal	*	*				
Va.	147. State Normal School for Women	*	*				
	148. Virginia Normal and Ind. Institute	*	*				
Wash.	149. State Normal, Bellingham	*			*		
	150. State Normal, Cheney	*	*		*		
	151. State Normal, Ellensburg	*			*		
W. Va.	152. State Normal, Athens	*	*				
	153. Glenville State Normal	*					*
	154. Marshall College	*	*				
	155. Storer College, State Normal (Pr.)		*				
	156. West Liberty Normal	*	*				
Wis.	157. La Crosse State Normal	*	*				*
	158. River Falls Normal	*	*				*
	159. Oshkosh Normal	*	*				
	160. Platteville Normal	*	*				*
	161. Stevens Point Normal	*	*				*
	162. Stout Institute, Menomonie	*	*				
	163. Superior State Normal	*	*				*
	164. Whitewater State Normal	*	*				*
	165. Nat'l German-Am. Teachers Seminary (Pr.) Milwaukee	*	*				*

State	Name of School	Time given to Methods	Length of Course in El. Agric. for Normal Students	No. in Course when last given
	135. Madison State Normal School	3 weeks	36 weeks	61
	136. Springfield State Normal		24 weeks	57
Tenn.	137. E. Tenn. State Normal		6 weeks	47
	138. Geo. Peabody College (Pr.)			
	139. Le Moyne Normal Institute (Pr.)			
	140. Morristown Normal and Industrial College (Pr.)			
	141. W. Tennessee State Normal		36 weeks	15
Texas	142. N. Texas State Normal	12 weeks	108 weeks	80
	143. Sam Houston State Normal Institute	12 weeks	36 weeks	150
	144. W. Texas State Normal		12 weeks	50
Utah	145. State School of Education (Univ. of Utah)		36 weeks	35
Vt.	146. Castleton State Normal	16 weeks	40 weeks	
Va.	147. State Normal School for Women	4 weeks	18 weeks	45
	148. Virginia Normal and Industrial Institute		51 weeks	200
Wash.	149. State Normal, Bellingham	Most	18 weeks	50
	150. State Normal, Cheney	9 weeks	18 weeks	130
	151. State Normal, Ellensburg			
W. Va.	152. State Normal, Athens			
	153. Glenville State Normal			
	154. Marshall College	3 weeks	19 weeks	45
	155. Storer College, State Normal (Pr.)		36 weeks	25
	156. West Liberty Normal		10 weeks	30
Wis.	157. La Crosse State Normal		20 weeks	19
	158. River Falls Normal		18 weeks	100
	159. Oshkosh Normal		12-36	46
	160. Platteville Normal	4 weeks	20 weeks	45
	161. Stevens Point Normal		18 weeks	21
	162. Stout Institute, Menomonie			
	163. Superior State Normal		20 weeks	46
	164. Whitewater State Normal		18 weeks	8
	165. National German-American Teachers Seminary, Milwaukee (Pr.)	7 weeks		

Observation School	No. of Grades	No. of Teachers	Nature Study in what Grades	Days per Week	Is Course Systematized?	Outline?	Length of Course in N. S. or El. Sc. for Normal Students	No. in Course when last given	Required of
*	8	4	5–8	3	Yes		12 weeks	45	
*	8	5					12 weeks	57	All
*	7	3		1–2			36 weeks	45	
*	8								
*	8	5							
*	8	10					12 weeks	18	
*	9	7	1–9	3	Yes		12 weeks		All
*	9	5	1–9	2–5			36 weeks		
*	9	6							
*	8		*				39 weeks	70	
*	8	3	1–8	1			48 weeks		All
*	9		1–9	2	Yes	Yes	18 weeks	15	All
*	5	2					68 weeks	200	All
*	10	8	1–3	5			9 weeks	40	
*	10	8	1–8		Yes		18 weeks	100	
*	8	7	1–7						
*	3–8	2							
*	7	2	1–7	2					
*	8	6	1–8	5			19 weeks	43	All
*	8	2	1–8				10 weeks		
*	8	7	1–8						
*	8	6	1–8	2–3	Yes	Yes	18 weeks		
*	Kg–10	8	3–9	5	Yes		18 weeks	41	
*	8	5	1–8	3	Yes	Yes	20 weeks	60	
*	8	8					18 weeks	21	
Public schools are used									
*	8	7					20 weeks	30	
*	Kg–8	8					18 weeks	35	
*	1–8		6–8				38 weeks	8	All

Required of	Number of Courses in Botany	Number of Courses in Zoology	Does the school prepare for H. S. Teaching?	How?	No. of Grads. Teaching in H. S.?	Which is what % of Grads.	What % of these teach Science	No. of Instr. in Sci. Dept.
	4	5	No					4
All	3	3	No		5			2
	3	3	Yes	H. S. Subj. required	48	75%	16%	3
	1	Biology 1	Yes					
			No					1
	1							2
	2	2	Agric.			50%		3
Agr. Stud.	2	5	No			10%		3
	3	2			10		Nearly all	4
All	Biology 3		No		20			2
								3
All			No		10	4%	30%	1
	Biology 3		Yes					4
All			No			5%	50%	2
	7	3	Yes	Prac. and Obs. 8th and 9th grade				
All	3	3	No		Few			2
	1	1	No					1
	1	1	No					2
	1	2	No			5%	4%	2
All	2	2	Yes	Practice Tchg.	2			3
All	2	1	No			2%		3
All	1	1	No					2
	3	3	Yes	Special course	50	12%	10%	3
	4	2	Yes	Obs. and Practice		15%		4
	1	1	Yes	3 yr. course		20%		2
Rural Sch.	1	3	Yes	Special course	80	20%		3
	1		Yes	Special courses		10%		3
	2	2	Yes	Special courses				2
	3	1	Yes	Special courses		10%		3
	1	1	Yes		4 or 5			2

RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins.
University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

THE RARE EARTHS.

BY H. C. KREMERS,
Division of Inorganic Chemistry, University of Illinois, Urbana.

In the fourth column of the periodic table there are four elements, scandium, yttrium, lanthanum, and ytterbium, which are members of a group of sixteen elements called the "Rare Earths." These elements are for the most part made up of a series of basic oxides which in basicity lie approximately between the metals of the alkaline earths and the trivalent metals, aluminium, iron, and chromium. The rare earths resemble each other very closely indeed, and their properties vary only slightly as we pass from member to member. With the exception of cerium in the ceric salts and of the recently discovered samarium and europium dichlorides, the oxides are mostly trivalent and their salts are only slightly hydrolysed in water. In the scheme of separation of the rare earths the following grouping is usually employed, the atomic weights and color of their salts also being given:

	Element.	Symbol.	Atomic Weight.	Color of Salts.
Cerium Group.	Lanthanum	La	139.0	Colorless
	Cerium	Ce	140.25	Cerous, colorless; ceric, orange to red
	Praseodymium	Pr	140.6	Green
	Neodymium	Nd	144.3	Red to reddish violet
	Samarium	Sa	150.4	Topaz yellow
Terbium Group.	Europium	Eu	152.0	Faint rose
	Gadolinium	Gd	157.0	Colorless
	Terbium	Tb	159.2	Colorless
Yttrium Group.	Dysprosium	Dy	162.5	Yellowish green
	Holmium	Ho	163.5	Yellowish with orange tint
	Yttrium	Y	89.0	Colorless
	Erbium	Er	167.7	Rose pink
	Thulium	Tm	168.5	Pale bluish green
	Ytterbium	Yb	172.0	Colorless
	Lutecium	Lu	174.0	Colorless
	Scandium	Sc	44.1	Colorless

The division into groups as here given is more qualitative than quantitative in nature, as we shall see later.

The history of the rare earths dates from about the year 1750, when Cronstedt, the Swedish mineralogist, discovered a new mineral mixed with copper pyrites which he called tungsten (heavy stone). Some fifty years later the mineral cerite was found to be the same as Cronstedt's tungsten. At about this time the mineral gadolinite was discovered by the Finnish chemist, Johann Gadolin, at Ytterby, Sweden. The discovery of gadolinite brought to light many new elements. Until 1884 the rare earth deposits seemed to be very limited. It was at this time that Auer von Welsbach took out a patent for the incandescent gas mantle, and an extensive search for more rare earth minerals began. It was soon discovered that the minerals were really quite widely distributed in nature. Gadolinite, a silicate of iron, beryllium, and yttrium group earths, is perhaps one of the most abundant sources of the yttrium group metals. It is found principally at Barringer Hill in Texas. Monazite sand, a rare earth phosphate containing varying amounts of thorium and silicon dioxide, is found extensively in North Carolina, Idaho, and the east sea shores of Brazil. This mineral is the principal source of the cerium group earths. Among the other less abundant rare earth minerals occurring in the same localities are samarskite, xenotime, euxenite, and fergusonite.

Since the properties of the different members of the rare earths are so very much alike, it is very difficult to separate them from each other. Many of the members have never been obtained in a pure state. As before mentioned, their properties vary slightly as we pass from member to member, and the methods of separation then employed are fractional crystallization and fractional precipitation. The separation into two groups is effected by the addition of sodium or potassium sulphate to the neutral sulphate solution of the rare earths. The members of the cerium group will form insoluble double sulphates of the following composition using the sodium salt: $\overset{III}{M}_2(SO_4)_3 \cdot 2Na_2SO_4 \cdot 2H_2O$. The yttrium and terbium groups will remain in solution. This method of separation is not entirely quantitative in nature. If, for instance, we wish to obtain a complete separation of the cerium group earths from the yttrium group earths, enough

sodium sulphate would have to be added to completely precipitate the cerium group and at the same time some of the yttrium group would be precipitated with the cerium group. The most difficult task by far is the separation of the individual members of each group. Two general methods of separation are usually employed. The first of these depends upon the slight variation in the basic character of the metals. The second method depends upon the difference in solubility of their salts. Under the first method we may make use of either one of two variations: Fractional precipitation with bases of different strength, and fractional decomposition of the nitrates by heat.

The rare earths when arranged according to their diminishing electropositive character have the following order: La, Ce, Pr, Nd, Y, Eu, Gd, Sa, Tb, Dy, Ho, Er, Tm, Yb, Lu, Sc. By means of a simple illustration, the principle underlying the method of fractional precipitation becomes quite evident. If we take two substances A and B in solution, and add a third substance C which is capable of precipitating both A and B, an excess of C will completely precipitate A and B from solution. If, however, we add a quantity of C insufficient to precipitate all of A and B, it is evident that the relative amounts of A and B precipitated

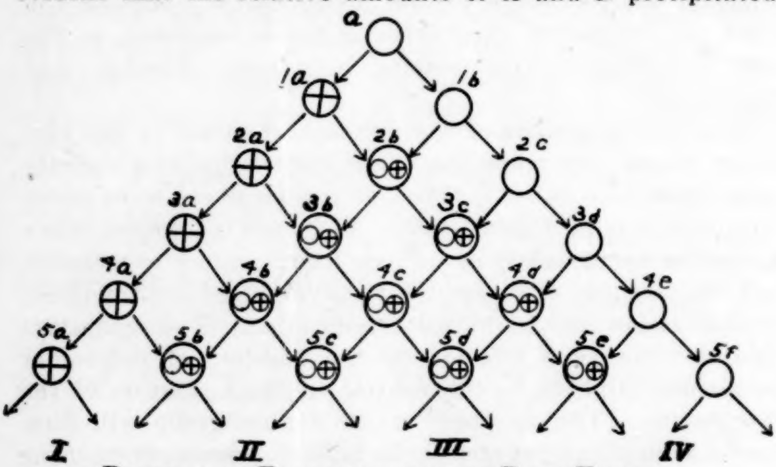


DIAGRAM OF FRACTIONATIONS OF RARE EARTHS.

will depend upon their chemical behavior with respect to C. If A is a stronger base than B, and C stronger than either A or B, it is evident that C will precipitate B more easily than A. This method is employed in the rare earths, using

such bases as ammonia, caustic soda, caustic potash, sodium carbonate, organic bases, etc. In the first partial precipitation the substance is separated into two parts, precipitate and mother liquor. The precipitate is redissolved and again partially precipitated. The mother liquor is also again partially precipitated. The method from then on will be made clearer by referring to the diagram. The circles represent the solutions, and the crossed circles represent the precipitates. A is divided into precipitate 1a and solution 1b. Each is in turn again partially precipitated. The precipitate of 1b and the soluble portion of 1a are united, forming 2b. 1b has also given solution 2c, and 1a has also given a new precipitate 2a. The operation may be continued until the desired separation has been obtained. It is thus seen that the more basic elements will collect toward the right according to the diagram, and the least basic toward the left. The order of separation of the yttrium group earths by fractional precipitation with ammonia is as follows, giving them in their order of decreasing ease of precipitation: Sc, Yb, Tm, Er, Ho, Tb, Y, Dy.

The method of fractional decomposition of the nitrates by heat depends upon the difference in basicity also. The rare earth oxides are converted into the nitrates by solution in nitric acid. This nitrate solution is then evaporated to dryness and the resulting mass fused. The mixture will decompose and the oxides least basic in character will separate out first. After partial decomposition has taken place, the undecomposed nitrate is dissolved in water, and the oxide remaining is dissolved in nitric acid, and both fractions again put through the same operation. Again by reference to the diagram above the method will be made clearer. Solution A is partially decomposed into the insoluble portion 1a and the soluble portion 1b. Fraction 1b is evaporated to dryness and partially decomposed. Fraction 1a will also again give a soluble and insoluble portion, and from this point on the method will become evident from the explanation in the case of fractional precipitation. The fusion of the nitrates is usually applied to the yttrium group and especially to separate yttrium from erbium and yttrium from holmium. The decomposition of the nitrates of the yttrium group in their order of decreasing ease is as follows: Sc, Yb, Er, Ho, Tm, Tb, Gd, Y.

The method of fractional crystallization makes use of the difference in solubility of the salts of the rare earths. Due again to the great similarity of the different elements of the rare earths, the salts formed are also isomorphous and it is only due to very slight differences in solubility that the different members may be separated. The mixture of salts is dissolved in water and evaporated down to such a point that about one-half of the salt will crystallize upon cooling. By a reference to the diagram above, the method of fractionation will be made clear. Again allowing the crystallized portion to be represented by the crossed circles and the solution by the plain circles, solution a, when partially crystallized, will give crystals 1a and solution 1b. More water is added to 1a and the crystals dissolved by warming. Solution 1b is also evaporated and crystallization allowed to take place. The mother liquor of 1b is poured into a new vessel 2c. The mother liquor from 1a is poured on the crystals from 1b. Now having three fractions—2a, 2b, and 2c—the entire operation is repeated. In most cases many hundred series of recrystallizations are required in order to effect a more or less complete separation. Again by reference to the diagram, it will be seen that after many series of recrystallizations the solution will have been divided into the least soluble portion I and most soluble portion IV, and portions intermediate II and III. Thus if we desired to obtain the earths which normally collected at the more soluble end, we could from time to time remove all other material which collected toward the least soluble end and continue the fractionation of the more soluble end.

The salts most commonly employed for fractional crystallization are the simple nitrates, double magnesium nitrates, sulphates, formates, oxalates, and bromates. In general the nitrates and the bromates have been found to give the better results. The simple nitrates and magnesium double nitrates are used for the cerium group. The type of salt formed by the magnesium double nitrates is the following: $2\overset{III}{M}(NO_3)_3 \cdot 3Mg(NO_3)_2 \cdot 24H_2O$, and the order of increasing solubility of the cerium group earths by the use of this salt is, La, Pr, Nd, Sa, Eu, Gd. The bromates are used for the yttrium group, giving the following order of increasing solubility, Tb, Dy, Ho, Y, Er, Tm, Yt, Lu, Sc. It is very difficult indeed, and perhaps impossible, to bring about a complete

separation by fractional crystallization alone, and only by combination with the other methods mentioned above can a more satisfactory separation be obtained.

One of the most important factors in the fractionation of the rare earths is to determine when our separation is complete, or has been carried to the desired end. It is very important to know, for instance, how the separation of holmium and dysprosium is progressing. Due to the great similarity of properties of the rare earths, the ordinary qualitative tests will not distinguish between the individual members. Two general methods may be used—a determination of the equivalents of the metals, or a spectroscopic examination of the solution.

During the fractionation of a series of rare earths we may determine the atomic weights or equivalents of certain fractions from time to time, and thus estimate the extent of the purity of the metal by its approximation to the true atomic weight. If, however, we desired to follow the separation of two elements whose atomic weights lie very closely together, we would encounter a very great difficulty.

The second method, which is very much more convenient, and more rapid and reliable, is to examine the solution with the spectroscope. In no department of chemistry has the method of spectrum analysis proved of more value than in the rare earths. Each colored salt of the rare earths gives very characteristic absorption lines, and we may thus obtain the approximate composition of a fraction by a simple examination of the absorption spectrum. It would, for example, be very simple to tell whether a fraction of holmium material contained any dysprosium. A more extensive and more difficult study may also be made by means of the emission spectra by either of three types—spark spectra, arc spectra, or cathode luminescence spectra.

Many of the rare earths have never been obtained in a very high state of purity, and the atomic weights given are in these cases none too reliable. The members of the cerium group have all been obtained in a fairly high state of purity and quite an extensive study has been made of their properties. Cerium, lanthanum, and neodymium, the most abundant elements of this group, are quite easily separated. The members of the yttrium group, with the exception of yttrium and to a limited extent erbium and dysprosium, have been

studied very little. Yttrium is by far the most abundant element of this group and perhaps even of all the rare earths as a whole. The relative amounts of ytterbium, lutecium, and scandium are very small indeed, and their chemistry has been worked out with the use of only a fraction of a gram of each of these elements. The knowledge of these elements is thus very limited, and the identity of some few of them even doubtful.

The salts of the rare earths are for the most part soluble. The oxalates, chromates, iodates, flourides, carbonates, and borates are insoluble. Many double salts exist, among which the double alkali sulphates and double magnesium and ammonium sulphates are important from their use for separa tions. The hydroxides resemble that of aluminium hydroxide. The trioxides, which are in most cases the most staple, are very readily soluble in acids. Lanthanum oxide when freshly ignited will hiss when moistened with water, and give off heat in much the same way as quicklime. Cerium dioxide is more staple than the sesquioxide and is insoluble in acids. Ceric basic nitrate may be separated from the neutral nitrate solution of the earths by oxidizing agents such as potassium permanganate and potassium chlorate. Cerium nitrate, together with thorium nitrate (the latter is sometimes considered as a rare earth) in the proportion of ninety-nine per cent of the thorium salt to one per cent of cerium, will upon ignition give a pure white oxide. Due to this latter property these two salts are used as the active constituent of the Welsbach gas mantle. Praseodymium also gives a higher oxide, which is black in color. Terbium also forms a higher oxide. These last two elements do not form salts in their higher state of oxidation.

Only a few of the rare earth metals have been prepared up to this time. Hillebrand and Norton [Pogg. a n n. *155*, 631; *156*, 466 (1875)] were the first ones to prepare the elements successfully by electrolysis of the fused chlorides. Hirsch [Met. Chem. Eng. *9*, 543 (1911)] prepared large quantities of cerium and studied its properties. By electrolysis of the mixed chlorides of the cerium group metals a mixture known as "Misch metal" is obtained. This mixture has very powerful reducing properties and finds some use in the thermite reduction. The melting points and specific gravities of the cerium group metals are approximately as follows:

	Melting point.	Sp. Gr.
Ce	623° C	7.0242
La	810° C	6.1545
Pr	940° C	6.4754
Nd	840° C	6.9563
Sa	1300–1400° C	7.75

The metals tarnish in moist air and decompose water rapidly at the boiling point. The cerium group metals form alloys with magnesium, zinc, aluminium, iron, and others. An alloy of cerium and iron has a remarkable property of emitting a shower of sparks when scratched. This alloy is used for pyrophoric purposes such as gas and cigar lighters. In general the rare earth metals, and their salts as well, have found very little commercial use. Some use is made of their salts and acids as catalyzers in industrial operations. Cerium salts have found a little use in photography andfor medicinal purposes. No doubt many more uses will be found for the rare earths as better and more rapid processes of separations are worked out. The mineral supply is abundant, and commercial operations involving the use of some of the rare earths, such as the Welsbach mantle company, are daily discarding many tons of valuable rare earth material as a waste product. Much opportunity is offered for research on these elements.

THE FUNCTIONS OF LIVING ORGANISMS.

By Wilbur F. Hoyt,

Normal School, Peru, Neb.

In teaching biology a number of years ago, I had the usual difficulty in getting my pupils to remember the functions of living beings as contrasted with nonliving organic and inorganic matter, until I happened upon the initial mnemonic word, America. I found this initial word a great help, and perhaps others may benefit by using it. These functions may be tabulated and defined as follows:

Assimilation—the transformation of food into materials ready to be used in tissue building.

Metabolism—the building up and tearing down processes of living beings.

Excretion—the riddance of waste materials of life processes.

Reproduction—the ability to originate a new organism.

Irritability—the power of perceiving a stimulus from the outside.

Contractility—the power to respond by motion to a stimulus.

Automatism—the power of self-movement, or motion in response to an impulse originating within itself.

Note that the first three and the last three functions are respectively and progressively related to each other. Reproduction is not so easily related to the others, but is probably intermediate.

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler,
Englewood High School, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication, we consider* accuracy, completeness, *and* brevity *as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

Reprinted Geometry Problems with Additional Solutions.

505. *Proposed by R. T. McGregor, Nord, Cal.*

Show that the circles described on the diagonals of a complete quadrilateral are coaxial. (For one solution, see Vol. XVII, No. 4.)

Solution by V. Rengan, Guntur, India.

Let ABCD be the quadrilateral, and let it be completed. Let DA and CB meet at E; AB and DC meet at F. Let AC and EF meet at K, DB intersect EF at H and AC and BD intersect in G.

It can easily be proved that each of the following sets of four points forms a harmonic range, viz.: DGBH, AGCK, EHFK.

[Note.—In a complete quadrilateral two of its opposite vertices form a harmonic range with two of the angular points of the diagonal triangle (GKH in this figure).—Editor.]

Lemma:

If four points L, M, N and P be in a harmonic range, any circle through L and N is orthogonal to the circle on MP as diameter.

[The proof of this lemma, submitted by Mr. Rengan, is omitted on account of lack of space.—Editor.]

Take the circle circumscribing the triangle GHK.

From the consideration of the H. R. (DGBH), using the lemma, any circle passing through G and H is orthogonal to the circle on BD as a diameter.

From the consideration of (AGCK), a circle passing through G and K is orthogonal to the circle on AC as a diameter.

Similarly, a circle through H and K is orthogonal to the circle on EF as a diameter.

But the same circle passes through G, H and K, and this is orthogonal to the three circles on AC, BD and EF as diameters, respectively. These circles have their centers on the same line, since in a complete quadrilateral the middle points of the diagonals are collinear. Hence the three circles on the diagonals belong to the same coaxial system.

507. *Proposed by C. E. Githens, Wheeling, W. Va.*

Given the center and radius of a circle, to find the side of a regular pentagon by means of the compass alone.

The construction of the required side is found on page 446 of the May (1917) number of SCHOOL SCIENCE, and is properly credited to the proposer. The proof there given was supplied by the editor of this department. The proposer submits the following simpler proof, which was mislaid in some way the first time.—Editor.

Proof by the Proposer.

Referring to the figure on p. 446, Vol. XVII:

Mark S as the middle point of KL.

Let O A $=r$, then AC $=r\sqrt{3}=$ AG $=$ DG.

$$OG=\sqrt{\overline{AG}^2-\overline{AO}^2}=r\sqrt{2}=KM.$$

$$MS=\sqrt{\overline{KM}^2-\overline{KS}^2}=\tfrac{1}{2}r\sqrt{5}.$$

$$OS=\sqrt{\overline{OK}^2-\overline{KS}^2}=r/2.$$

$$OM=MS-OS=r/2(\sqrt{5}-1).$$

$$AM=\sqrt{\overline{AO}^2+\overline{OM}^2}=\sqrt{r^2+[r/2(\sqrt{5}-1)]^2}=r/2\sqrt{10-2\sqrt{5}}.$$

This proof was also submitted recently by Elmer L. Hunting Canisteo, N. Y.

PROBLEMS FOR SOLUTION.

Algebra.

516. *Proposed by Daniel Kreth, Wellman, Ia.*

An estate was divided among A, B, and C in the following manner: A received a dollars and one n-th of the remainder; B received $2a$ dollars and one n-th of what remained after A's share and $2a$ dollars had been deducted; C received $3a$ dollars and one n-th of what remained after the shares of A and B and $3a$ dollars had been subtracted. By this arrangement there was nothing left. What was the value of the estate?

I. *Solution by R. M. Mathews, Riverside, Cal.*

A receives $\frac{x}{n}+a\left(1-\frac{1}{n}\right)$ and the remainder is $r_1=(x-a)\left(1-\frac{1}{n}\right)$

B receives $\frac{r_1}{n}+2a\left(1-\frac{1}{n}\right)$ and the remainder is $r_2=(r_1-2a)\left(1-\frac{1}{n}\right)$

C receives $\frac{r_2}{n}+3a\left(1-\frac{1}{n}\right)$ and the remainder is $r_3=(r_2-3a)\left(1-\frac{1}{n}\right)$

Since $r_3=0$ and $1-\frac{1}{n}\neq 0$, $n\neq 1$

$$\therefore\ r_2=3a.$$

$$\therefore\ r_1=\frac{a(5n-2)}{n-1},$$

$$\text{and so } x=\frac{a(6n^2-4n+1)}{(n-1)^2}.$$

II. *Solution by N. P. Pandya, Sojitra, India.*

Let e dollars be the value of the estate. Then

$$\text{A's share}=a+\frac{e-a}{n}=\frac{a(n-1)}{n}+\frac{e}{n}.$$

$$\text{B's share}=2a+\frac{e-2a-(e-a)/n-e/n}{n}$$

$$=2a-\frac{2a}{n}-\frac{a(n-1)}{n^2}+\frac{e}{n}-\frac{e}{n^2}$$

$$=\frac{a(n-1)(2n-1)}{n^2}+\frac{e(n-1)}{n^2}.$$

C's share $=3a$.

After giving $3a$ dollars to C nothing would be left, because if there be any remainder, after giving away $1/n$ of it to C something would

still remain, which is not warranted by the conditions of the problem.

$$\therefore\ e=3a+\frac{a(n-1)(2n-1)}{n^2}+\frac{e(n-1)}{n^2}+a\frac{n-1}{n}+\frac{e}{n},$$

whence $e=\dfrac{a(6n^2-4n+1)}{(n-1)^2}$.

III. *Solution by the proposer.*

Suppose the letters A, B and C represent the shares of A, B and C, respectively.

$$\begin{aligned}
C&=3a.\\
B&=2a+(B+C-2a)\frac{1}{n}\cdot\\
nB&=2na+B+C-2a.\\
(n-1)B&=2na+3a-2a.\\
\therefore\quad B&=\frac{2n+1}{n-1}a.\\
A&=a+(A+B+C-a)\frac{1}{n}\cdot\\
nA&=na+A+B+C-a\\
(n-1)A&=na+\frac{2n+1}{n-1}a+2a\\
&=\frac{(n-1)(n+2)a+(2n+1)a}{n-1}\\
\therefore\quad A&=\frac{n^2+3n-1}{(n-1)^2}a\\
\therefore\ A+B+C&=\frac{(6n^2-4n+1)a}{(n-1)^2}.
\end{aligned}$$

517. *Proposed by N. P. Pandya, Sojitra, India.*

Factor $x^{2n}-x^ny^n+y^{2n}$, n being odd.

I. *Solution by R. M. Mathews, Riverside, Cal.*

$$x^{2n}-x^ny^n+y^{2n}=0,$$

$$x^n=y^n(\tfrac{1}{2}\pm\tfrac{1}{2}\sqrt{-3}).$$

$$\therefore\ x^{2n}-x^ny^n+y^{2n}=(x^n+\omega y^n)(x^n+\omega^2y^n),$$

where ω is one of the complex roots of unity.

II. *Solution by DeWitt T. Weaver, Middletown, Va.*

$$\begin{aligned}
x^{2n}-x^ny^n+y^{2n}&=(x^n+y^n)^2-3x^ny^n\\
&=[x^n+y^n-\sqrt{3x^ny^n}]\,[x^n+y^n+\sqrt{3x^ny^n}]\\
&=[x^n+y^n-x^{\frac{n-1}{2}}y^{\frac{n-1}{2}}\sqrt{3xy}]\,[x^n+y^n+x^{\frac{n-1}{2}}y^{\frac{n-1}{2}}\sqrt{3xy}].
\end{aligned}$$

$\dfrac{n-1}{2}$ is an integer, since n is odd.

Suggestion by the Editor.

The two solutions above, which were the only ones received, answer the question raised by the problem in two different ways. However, neither set of factors has rational coefficients and the Editor presumes that rational factors were in the mind of the proposer. Hence, the following:

Consider the factors of $x^{3n}+y^{3n}$, n being odd. These may be written in two ways, viz.,

$$x^{3n}+y^{3n}=(x+y)F_1\cdot F_2\equiv(x+y)F_3\cdot F_4,\quad\text{where}$$

$$F_1\equiv x^2-xy+y^2,\quad F_2\equiv x^{3n-3}-x^{3n-6}y^3+x^{3n-9}y^6-\cdots+y^{3n-3},$$

$$F_3\equiv x^{n-1}-x^{n-2}y+x^{n-3}y^2-\cdots+y^{n-1},\quad F_4\equiv x^{2n}-x^ny^n+y^{2n}.$$

It is evident that further factoring is possible.

If $n=1$, $F_1 \equiv F_4$ and $F_2 \equiv F_3 = 1$.

If $n=3$, $F_1 \equiv F_3$ and $F_2 \equiv F_4$.

If $n \geqq = 5$, $3n-3 > 2n > n-1$ and we must have either F_1 a factor of F_3 and F_4 a factor of F_2; or F_1 a factor of F_4 and F_3 a factor of F_2. We are not concerned with the first possibility but with the conditions under which F_1 is a factor of F_4, *i. e.*, x^2-xy+y^2 a factor of $x^{2n}-x^ny^n+y^{2n}$.

It can be proved by mathematical induction that if n is of the form $3k$, F_1 is not a factor of F_4, but if n is of the form $3k+1$ or $3k+2$, the result becomes

$$x^{2n}-x^ny^n+y^{2n}=(x^2-xy+y^2)(x^{2n-2}+x^{2n-3}y-x^{2n-5}y^3-x^{2n-6}y^4+ x^{2n-8}y^6+x^{2n-9}y^7- \cdots -x^{n+2}y^{n-4}-x^{n+1}y^{n-3}+x^{n-1}y^{n-1}- x^{n-3}y^{n+1}-x^{n-4}y^{n+2}+ \cdots +y^{2n-2})$$

for $n \equiv 1 \pmod 3$, or

$$x^{2n}-x^ny^n+y^{2n}=(x^2-xy+y^2)(x^{2n-2}+x^{2n-3}y- \cdots -x^ny^{n-2}-x^{n-1}y^{n-1}-x^{n-2}y^n+ \cdots +y^{2n-2})$$

for $n \equiv 2 \pmod 3$.

For example,

$$x^{14}-x^7y^7+y^{14}=(x^2-xy+y^2)(x^{12}+x^{11}y-x^9y^3-x^8y^4+x^6y^6- x^4y^8-x^3y^9+xy^{11}+y^{12})$$

$$x^{10}-x^5y^5+y^{10}=(x^2-xy+y^2)(x^8+x^7y-x^5y^3-x^4y^4-x^3y^5+xy^7+y^8)$$

This is not intended to be a complete discussion. If any one is interested in factoring the expression further, the results will be published, if correct.

Geometry.

518. *Proposed by George Blanchard, Portland, Oregon.*

Given one angle of a triangle and the sum of an adjacent and opposite side and the radius of the inscribed circle, to construct the circle. (From *Nixon's Euclid.*)

Solution by N. P. Pandya, Sojitra, India.

Let the given angle be B, r the inradius, $p=b+c$ (given).

$$\text{Then } r=\frac{\triangle}{s}=\frac{ac\sin B}{2s}=\frac{(s-a)ac\sin B}{2s(s-a)}=\frac{(2s-2a)ac\sin B}{4bc\cos^2 \frac{1}{2}A}$$

$$=\frac{(b+c-a)a\sin B}{2b(1+\cos A)}=\frac{(p-a)a\sin B}{2(b+b\cos A)}=\frac{(p-a)a\sin B}{2(b+c-a\cos B)}$$

$$=\frac{(p-a)a\sin B}{2(p-a\cos B)}.$$

This equation determines a. Hence s, and therefore $\triangle s$ are known, *i. e.*, $ac \sin B$ is known. This gives c. Therefore, the triangle is determined.

The Editor suggests the following.

Solving the above equation for a, we obtain

$$a=\frac{p}{2}+r\cot B+\sqrt{\left(\frac{p}{2}+r\cot B\right)^2-2p\frac{r}{\sin B}}$$

which can be constructed in time. Having the length of a, the triangle may easily be constructed as follows:

Describe the circle with radius r. Draw two radii making an angle equal to the supplement of B. Draw the tangents from their extremities. The intersection of these tangents marks the vertex of the angle B of the triangle. Extend one of the tangents from B beyond the point of tangency as side a to the required length and from its extremity draw the other tangent from that point to the circle. Completion of the triangle is obvious.

519. *Proposed by R. T. McGregor, Nord, Cal.*

A and B are two fixed points and a variable circle through them cuts a fixed circle in C and D. Show that the line joining the intersection of AC, BD and AD, BC passes through a fixed point.

Solution by N. P. Pandya, Sojitra, India.

Let AC, BD meet in E; AD, BC in F; DC, EF meet AB in H and G, respectively.

Since AB is the radical axis of the variable circles, AB will be concurrent with all lines CD which are the radical axes of the fixed circle with the variable circles.

$\therefore$ H is a fixed point. $\therefore$ BH : HA is a fixed ratio.

But A, B, C, D, E, H are the vertices of a complete quadrilateral.

$\therefore$ HAGB is a harmonic range, *i. e.* BG : AG = BH : AH. G divides AB in a fixed ratio, hence G is a fixed point and all lines EF pass through G.

Trigonometry.

520. *Proposed by Clifford N. Mills, Brookings, S. D.*

If the sides of the angles of a triangle be in arithmetical progression, the product of the tangents of half the greatest and half the least angle is $\frac{1}{3}$.

I. *Solution by Murray J. Leventhal, New York City.*

If sin A, sin B and sin C are in arithmetical progression,

$$\sin A + \sin C = 2\sin B. \tag{1}$$

In any triangle

$$\sin A + \sin B + \sin C = 4\cos \tfrac{1}{2}A\cos \tfrac{1}{2}B\cos \tfrac{1}{2}C \tag{2}$$

From (1) and (2)

$$\cos \tfrac{1}{2}A\cos \tfrac{1}{2}C = \frac{3\sin B}{4\cos \frac{1}{2}B} = \frac{3\sin \frac{1}{2}B}{2} \tag{3}$$

In any triangle

$$\sin A + \sin C - \sin B = 4\sin \tfrac{1}{2}A\sin \tfrac{1}{2}C\cos \tfrac{1}{2}B \tag{4}$$

From (1) and (4)

$$\sin \tfrac{1}{2}A\sin \tfrac{1}{2}C = \frac{\sin B}{4\cos \frac{1}{2}B} = \tfrac{1}{2}\sin \tfrac{1}{2}B \tag{5}$$

Dividing (5) by (3),

$$\tan \tfrac{1}{2}A\tan \tfrac{1}{2}C = \frac{\frac{1}{2}\sin \frac{1}{2}B}{\frac{3\sin \frac{1}{2}B}{2}} = \frac{1}{3}.$$

II. *Solution by L. E. Mensenkamp, Freeport, Illinois.*

Denote the three angles of the triangle by A, B, and C, where A > B > C.

We have given, $\sin A - \sin B = \sin B - \sin C.$ (1)

By the law of sines, $\sin A = Ka$, $\sin B = Kb$, and $\sin C = Kc$. Therefore, condition (1) becomes

$$a - b = b - c, \text{ or } 2b = a + c. \tag{2}$$

Using the well known formula, $\tan A/2 = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}$, where $a+b+c=2s$, we obtain

$$\tan A/2 \tan C/2 = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}} \cdot \sqrt{\frac{(s-a)(s-b)}{s(s-c)}} = \frac{s-b}{s}$$

$$= 1 - \frac{2b}{a+b+c}. \tag{3}$$

Eliminating $a+c$ from (3) by means of (2), we get

$$\tan A/2 \tan C/2 = 1 - \frac{2b}{3b} = \tfrac{1}{3},$$

which is the desired result.

CREDIT FOR SOLUTIONS.

496, 497, 500, 501, 502, 503, 505. V. Rengan, Guntur, India.
506. John R. Howland, N. P. Pandya.
508, 509, 510. N. P. Pandya.
512. W. B. Campbell.
516. Daniel Kreth (4), Murray J. Leventhal, Robert C. MacDonald, R. M. Mathews, N. P. Pandya, DeWitt T. Weaver. (9)
517. R. M. Mathews, DeWitt T. Weaver. (2)
518, 519. N. P. Pandya.
520. Murray J. Leventhal, R. M. Mathews, L. E. Mensenkamp, N. P. Pandya, DeWitt T. Weaver. (5)

31 solutions.

PROBLEMS FOR SOLUTION.

Algebra.

531. *Proposed by G. L. Wagar, Mount Hermon, Mass.*

Given that the sum of the following four factors is -1, find (1) the product of the first pair; (2) the product of the second pair; (3) the product of the sum of the first pair by the sum of the second pair.

$$x + x^4 + x^{13} + x^{16}$$
$$x^2 + x^8 + x^9 + x^{15}$$
$$x^3 + x^5 + x^{12} + x^{14}$$
$$x^6 + x^7 + x^{10} + x^{11}$$

Taken from *Teachers' Handbook of Algebra*, by McLellan.

Geometry.

532. *Proposed by R. M. Mathews, Riverside, Cal. Lemma for* 513.

A variable circle with center on the line 1 and passing through a fixed point P, cuts a fixed circle C in A and B. Prove that the common chord AB and the perpendicular to 1 through P intersect in a fixed point R.

533. *Proposed by Daniel Kreth, Wellman, Iowa.*

In the triangle ABC perpendiculars to AC and BC, respectively, are drawn from C intersecting AB in E and D. $\angle ACE = \angle BCD = 90°$; CD $=l$, CE $=m$, AD $=n$, and BE $=p$. Find the remaining parts of the triangle.

534. *Proposed by J. A. van Groos, Portland, Oregon.*

Of the three inscribed squares on the three sides of a triangle, the largest square is on the smallest side.

535. *Proposed by Frank Edwin Wood, Albuquerque, N. M.*

Let PA and PB be two chords of a circle, let PC be the perpendicular to AB, then $\overline{PA} \cdot \overline{PB} = \overline{PC} \cdot 2R$, where R is the radius.

Request.

Will new contributors please take note of the rules published in recent issues?

DEPARTMENT OF MATHEMATICS QUESTIONS AND ANSWERS.

Conducted by Herbert E. Cobb.
Lewis Institute, Chicago.

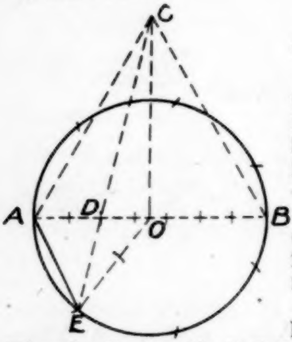
For the many mathematics teachers who are entering the profession every year, and for those who after some years of work and study find themselves at times in doubt concerning questions of subject matter, methods, devices to interest pupils, the history, psychology, or bibliography of mathematics, special problems and the like, this department is established. Probably the question that is perplexing some teacher at the present time has been faced and successfully answered by many others.

It is hoped that many will make use of this opportunity, not only to send in questions, but also to furnish replies to questions already published. Brief discussions, from two hundred to three hundred words, of points brought out in the questions will be appreciated. Address all communications to H. E. Cobb Lewis Institute, Chicago.

Answers.

4. Is there any proof for the methods given in mechanical drawing for the construction of regular polygons of seven, nine, eleven, and so on, sides?

Answer.—Two such methods follow. Neither can be proved correct, for analysis with the aid of trigonometry shows both to be approximate.



Problem.—To inscribe a regular polygon of n sides in a circle.

First Method.—Upon the diameter AB of the circle O construct an equilateral $\triangle$ ABC. Divide AB into n equal parts and counting from A call the second point of division, D; produce CD to intersect the circle at E. Then AE is a side of the required polygon.

Second Method.—Erect a $\perp$ to AB at O and upon it take OC $=1\frac{3}{4}$ radius. Steps 2, 3, and 4 are the same as in the first method.

Analysis of Problem.—For convenience, let radius equal 1.

Then by first method, OC $=\sqrt{3}=1.732$; and by second method, OC $=1.75$.

To prove that both methods are approximate, suppose AE to be the exact side of a regular polygon of n sides, the diameter to be divided as in step 2 of methods above, and ED produced to intersect the perpendicular bisector of AB at C; then compute OC. To do so draw EO. Then in $\triangle$ EOD, $\angle \text{DOE}=\frac{360}{n}$, DO $=\frac{n-4}{n}$, and OE $=1$. Solve by Law of Tangents for $\angle$ EDO. Then in rt. $\triangle$ DOC $\angle$ ODC $=180^0-<\text{EDO}$, and DO $=\frac{n-4}{n}$, whence OC $=\frac{n-4}{n}\tan \text{ODC}$.

For various regular polygons the corresponding values of OC (to two decimal places) will be found to be as follows:

For $r=1$ and AE an exact side of regular polygon of n sides.

n	—OC
3	$\sqrt{3}=1.73$
4	Indeterminate
5	1.74
6	$\sqrt{3}=1.73$
7	1.72
8	1.71
9	1.70
10	1.69
11	1.68

The table shows that the first method is exact only when $n=3$, 4, or 6, and that the second method is never exact.

Question.

5. Is there any compendium treating exclusively or mostly of labor-saving methods in algebra? If there is none, is it convenient to make a list of short cuts so as to cover many frequently occurring cases?—[*N. P. Pandya, Sojitra, India.*

ALASKA MAY INCREASE TIN OUTPUT.

The known tin deposits in the United States are few, but Alaska is something of a contributor to our much-needed tin demand. Alaska lode tin was discovered, curiously enough, by a geologist of the Geological Survey, Department of the Interior, as he was helping two prospectors by crudely smelting in a camp cup a piece of peculiar looking ore, which the prospectors rightly suspected to be tin. Specimens of stream tin were also collected by Survey geologists in Alaska in 1900, which was before this metal was known to occur in the territory. Soon after that time prospecting for stream tin became active, and since 1902 nearly 1,000 tons of metallic tin have been produced.

The Survey has given special attention to tin in Alaska. Last year's output was 139 tons, an increase of 37 tons over 1915, but it is the hope of Government officials that with the present high prices the production for the present year may total as much as 300 tons. In the Seward Peninsula, where placer tin was first mined, the source of this stream tin has been discovered and lode mining is now being carried on. In the other known Alaskan tin locality—the Hot Springs placer-tin region—Geological Survey men are this year searching for the source, and are also urging the miners to save all their stream tin.

Stream tin is rather widely distributed in the Hot Springs district, but as yet few of the gold placer miners make any pretense of saving it. An effort is being made by the Government geologists now on the ground to induce the miners to save and ship this stream tin, which should materially increase the total output from the territory. Placer mining in the Hot Springs district can be carried on for about three months in summer. In view of the great need of tin in the United States, it is hoped that the Alaska miners will make every effort to increase their output.

The Geological Survey has just issued a report on tin, manganese, platinum, aluminum, tungsten, chromite, and other important minerals—Bulletin 666, "Our Mineral Supplies." This bulletin is published in the form of brief leaflets or separate chapters. The tin report is Bulletin 666-U, and the chapter on Alaska's mineral supplies, Bulletin 666-P.

NOTICE TO ALL MEMBERS OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

A Committee on Necrology has been appointed by the Central Association, whose duty is to report at the annual meeting the death of any of our members.

The request is therefore made that notice be sent to the undersigned of the death of any member of the Central Association of Science and Mathematics Teachers occurring since November, 1916. Accompanying this should be sent a statement of the work and achievements of the deceased person, so that appropriate mention may be made in the annual report.—[WILLIS E. TOWER, *Chairman, Committee on Necrology, Englewood High School, Chicago.*

DISTRIBUTION OF ENERGY IN THE VISIBLE SPECTRUM OF AN ACETYLENE FLAME.

Data on the distibution of energy in the visible spectrum of a standard source of light are frequently needed in connection with investigations in physiology, in psychology, and in physics; especially in photoelectric work, in photography, and in the photometry of faint light sources. The acetylene flame appears to be a promising source of light, having a high intensity and a white color.

Numerous requests having come to the Bureau of Standards, Department of Commerce, for data of this type, an investigation was made to supply the information desired, and the results have been published in *Scientific Paper, No. 279,* just issued. The paper gives data on the distribution of energy in the visible spectrum of a cylindrical acetylene flame operated under specified conditions.

Persons interested may obtain copies without charge from the Bureau of Standards, Washington, D. C.

McINTOSH STEREOPTICON COMPANY.

Successful science teaching cannot be accomplished without the teacher having at his command a good, up-to-date projecting lantern. Yet this will avail him nothing unless there is a collection of first-class slides, by means of which the instructor may illustrate the subject which he is teaching. There are many firms which deal in lantern slides of one kind and another, but there are none, however, which possess a larger and more complete assortment, covering all the sciences taught in high school, than the McIntosh Stereopticon Company, Chicago. In their Catalogue S, recently issued, one is surprised to find such an extended variety of slides listed. This catalogue, which will be sent free on request, contains full directions for ordering, using, and caring for slides. These people will make perfect slides from cuts, drawings, or photographs, at prices which are as low as those of any other company. The reputation of this firm is a guarantee of first-class work and honest treatment. In this catalogue are listed over 7,000 slides, bearing upon the subjects of anatomy, astronomy, chemistry, earth science, natural history, physics, physiology, histology, zoology, hygiene, sanitation, preventable diseases, bacteriology, and pathology. Covering such a large field of subjects, this corporation has used all of the best influences at its command to secure a list of slides touching upon a range of topics not approached by other firms. Teachers will not be making mistakes when they order this stereopticon material from this old and reliable house.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones,
University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal. Send your second term or final examination papers now.*

Acknowledgment.

The receipt of examination questions is gratefully acknowledged from Philo F. Hammond, University of Alberta, Edmonton South, Lyman C. Newell, Boston University, Walter N. Lacy, Anglo-Chinese College, Foochow, China, and R. A. Burtnett, High School, Champaign, Ill.

Questions and Problems for Solution.

254. *Published in March, 1917.*

261-2. *Published in April, 1917.*

Please refer to these problems and send in solutions.

275. *Proposed by Daniel Kreth, Wellman, Iowa.*

A stream of water, 4 feet deep, flows at the rate of 5 ft. per second. It is required to lower the water by means of a "drop" so that the bottom of the stream below the "drop" is 4 ft. lower than it is above the "drop." What must be the dimensions of the pit below the "drop" so that the water acts as a cushion to prevent the water striking the ground?

276. *Proposed by John C. Packard, Brookline, Mass.*

Why does the moon appear larger near the horizon than when overhead?

277. *Proposed by W. H. Magill, Westtown, Pa.*

In a Wheatstone bridge the A arm has a resistance of 6 ohms, the R arm 3 ohms, the B arm 3 ohms, the X arm 6 ohms, and the galvanometer is replaced by a resistance of 3 ohms. What is the total resistance between the battery binding posts of the bridge and what current flows through the 3 ohms which replace the galvanometer when an E. M. F. of 9 volts is used?

278. *The College Board comprehensive June examination in physics appears below.*

Please comment upon it as to (*a*) length; (*b*) reasonableness for boys and girls of college entrance age; (*c*) What questions should have been omitted as unsuitable? (*d*) Does it conform to our teaching? (*e*) Should our teaching conform to it?

Answers from all parts of the country, whether you prepare for college entrance examinations or not, will be appreciated.

College Board Comprehensive Examination in Physics, Friday, June 22, 1917.

A teacher's certificate covering the laboratory instruction must be presented as a part of the examination, unless the laboratory notebook is to be presented at a laboratory examination.

Answer ten numbered questions, distributed as follows: three from Group I, two from Group II two from Group IV, two from Group V, and one of the remaining questions.

The number in parentheses before each question indicates the number of credits assigned to it.

Show clearly the method by which you obtained your answers to problems and state the units used in each case.

Attach to the answer, in each case, the number and letter used in the printed paper.

Group I.

1. If a 10-gram body should start from rest down a frictionless plane and gain in six seconds a velocity of 120 cm. per second, what would be:
   (*a*) (2) the total distance covered?
   (*b*) (2) the distance covered during the first second?
   (*c*) (2) the distance covered during the last second?
   (*d*) (2) the acceleration?
   (*e*) (2) the kinetic energy at the end of six seconds?
2. (*a*) (2) Define horse-power.
   (*b*) (6) An automobile running at the constant rate of 30 miles per hour exerts a force of 200 lbs. in the direction of motion. What is the power supplied to the wheels of the automobile?
   (*c*) (2) If the efficiency of the transmitting mechanism is 75 per cent, what horse-power is the engine developing?
3. (*a*) (7) A uniform plank, AB, 12 ft. long and weighing 80 lbs., is used as a "diving-board." End A is fastened to the floor of a float. Four ft. from A the plank rests on the slightly raised edge C of the float, so that 8 ft. of the plank projects over the water. A boy weighing 100 lbs. stands on end B and a second boy of 60 lbs. weight, 1 ft. from him. Under these conditions, how strong must the fastenings be at A?
   (*b*) (3) What is the direction and magnitude of the force exerted at C? Make a diagram.
4. (*a*) (7) A building is being moved on rollers on a level road by means of a capstan (a form of the wheel-and-axle machine). Two horses, each exerting an effective pull of 125 lbs., are attached to the capstan bar (wheel) at a distance of 7 ft. from the center of the drum (axle). This drum, on which the rope attached to the house is wound, is 6 in. in diameter. If the coefficient of friction of the building on the rollers is 0.3, what is the weight of the building? Neglect other friction.
   (*b*) (3) If the horses make 5 circuits per minute, what is the rate of working of the team?
5. (*a*) (7) A hollow sphere of glass weighs 500 gm. in air and requires a force of 1,000 gm. to hold it under water. If the density of the glass is 2.5 gm. per c. c., what is the volume of the space inside?
   (*b*) (3) Is it harder to lift a stone in air than when it is under water? Why?

Group II.

6. (10) An automobile tire contains 1,500 cu. in. of air at 12° C. and a pressure of 90 lbs. per sq. in. Driving the car causes the air in the tire to be heated to 33° C. What is the pressure, assuming the air in the tire to have now a volume of 1,530 cu. in.?
7. (*a*) (4) Describe the processes by which heat passes from the steam in a steam radiator to the objects in the room.
   (*b*) (6) Steam at 100° C. is passed into a 55-kg. iron radiator. Calculate the weight of steam condensed in heating the radiator from 5° C. to 100° C. (Specific heat of iron = 0.11.)
8. (*a*) (4) Describe a laboratory experiment to determine the latent heat of vaporization of water.
   (*b*) (4) What quantities must be determined and how would you use these in calculating the result?

(*c*) (2) Mention two important sources of error which must be guarded against.

Group III.

9. (*a*) (5) Name and define three characteristics by which different sounds are distinguished from each other.
(*b*) (5) Explain how each of these characteristics may be altered in the case of a vibrating string.

Group IV.

10. (*a*) (4) Show how the intensity of a source of light may be measured.
(*b*) (1) What is the unit of intensity of light?
(*c*) (5) If a light 6 ft. away is illuminating your book, how far away should a light 16 times as bright be placed to produce the same illumination?

11. At what distance from a double convex lens of focal length 12 in. must an object be placed to cause a real image:
(*a*) (4) of twice the length of the object?
(*b*) (3) of half the length of the object?
(*c*) (3) of the same length as the object?

12. (*a*) (3) What is a spectrum and how is it produced?
(*b*) (2) What are the Fraunhofer lines in the solar spectrum?
(*c*) (2) What do these lines indicate?
(*d*) (3) Explain the appearance of each color in the American flag when placed in pure blue light; when placed in pure red light.

Group V.

13. (*a*) (2) Describe a leaf electroscope.
(*b*) (3) Describe how the electroscope may be charged by the method of induction.
(*c*) (3) Explain the various steps of the process.
(*d*) (2) Explain how the electroscope is used to tell that a body is positively charged.

14. A 40-watt incandescent lamp is connected to a 100-volt circuit:
(*a*) (3) What current passes through the lamp?
(*b*) (2) If three such lamps are connected in parallel in the above circuit, what current passes through each lamp?
(*c*) (2) If the three lamps are connected in series, what current passes through each lamp?
(*d*) (3) If the three lamps are connected in parallel and used 10 hours each day for 4 weeks, and the cost is 8 cents per kilowatt-hour, what will be the total cost?

15. (*a*) (1) Whose name is associated with the discovery of induced currents?
(*b*) (2) What is Lenz's Law for the direction of induced currents?
(*c*) (2) Name two machines or pieces of apparatus that depend upon induction for their usefulness.
(*d*) (1) In what other way are currents of electricity commonly produced?
(*e*) (1) Which was discovered first?
(*f*) (1) Which is the more important today?
(*g*) (2) Give some reasons for your last answer.

Solutions and Answers.

244. c. *Solution by J. P. Drake, Emporia, Kan.*

The reaction is $8+125 = 133 +$ a series of reactions.

This series is $\frac{133}{2}+\frac{133}{4}+\frac{133}{8}+\frac{133}{16}+ \ldots \ldots \frac{133}{\infty}$.

The sum of this series is 133, making the total reaction 266.

One-half of this reaction and of the 250-lb. load is supported by each rope. The force then necessary to support the load in air = 8+125+133 = 266 lbs.

Also solved by P. C. Hyde, Newark Academy, Newark, N. J.

Tension on each rope	124+124+2+8 =	258 lbs.
Balance reading	258+8 =	266 lbs.
Check: Upward forces on two ropes		516 lbs.
Weight of man, weight, and pulley	250	lbs.
Push of man (counteraction)	266	516 lbs.

REMARKS: In B and C the fact that all the weights concerned are ultimately supported by the long rope made fast overhead, and that the tension of rope on each side of pulley is the same if the pulley is at rest, gives at once the value of that tension. For the man to maintain an upward pull on the balance he must exert an equal push downward (I have called it "counteraction" because the reaction is the pull of the balance on him) in addition to his weight.

The balance readings accordingly are: (*a*) 71 lbs., (*b*) 142 lbs., (*c*) 266 lbs. Some man!

258. What is the candle power of a source of light which gives a photometric balance when it is three times as far away from the photometer screen as a 16 candle power standard?

Solution by R. T. McGregor.

Also solved by Annie Cloyd.

Let x equal the candle power of the light. Then, since the intensity of illumination varies directly as the intensity of the light and inversely as the square of the distance of the light, we have $\frac{x}{3^2} = \frac{16}{1^2}$, or $x = 144$ candle power.

259. *Proposed by Annie Cloyd, Sewickley, Pa.*

Cannot something be done to avoid the repetition that high school students who have had preparatory chemistry are required to make in their first year college work?

Answer by R. W. Boreman, Parkersburg, W. Va.

Presumably most of those students who elect chemistry in college do so because they expect to specialize to some extent in this subject, and even though they have had it in high school, there is such diversity in the equipment, texts used and even in instructors, that a review is usually needed. One instructor emphasizes descriptive material; another problems; another the theoretical consideration of chemistry; some have some work in qualitative analysis, while others have none, so it becomes imperative that those who take chemistry in college should have a course somewhat similar to that given in the high schools, for the sake of standardization if nothing else. If the work could be made a half year course, or less for those who had had chemistry in the high school, and devote the second half year to qualitative analysis almost exclusively, with a few of the fundamental considerations of physical chemistry, I believe it would be a marked improvement over the present system.

260. *Proposed by C. T. Beach, Tunkhannock, Pa.*

In the case of a boy rowing a boat, what class of lever do we have represented?

Answer by J. P. Drake, Emporia, Kansas.

Also answered by R. W. Boreman.

A boy rowing a boat uses a second class lever as the fulcrum is in the water. Since the water does not hold the oar absolutely still there is a suggestion of a first class lever also.

263. *From a College Board Comprehensive Physics Examination.*

A shell weighing 6 lbs. fired from an anti-aircraft gun aimed

vertically upward has a muzzle velocity of 1,200 ft. per sec. If the shell bursts beside an aeroplane 3 sec. after leaving the gun, how high is the aeroplane?

Solution by David B. Munroe, Laton, California.

Also solved by R. W. Boreman, J. P. Drake, and R. T. McGregor.

Dis. = vel. $\times$ time − attraction of gravity.
= vt. − $\frac{1}{2}$ gt.^{2}
= $1,200\times3-\frac{1}{2}\ 32.2\times9$.
= $3,600-144.9$.
= 3,455.1 ft. above earth.

264. A boy weighing 110 pounds sits in a hammock whose ropes make angles of 60° and 30° respectively with the horizontal. Find the tension in each rope.

Solution by R. W. Boreman, Parkersburg, W. Va.

Also solved by J. P. Drake, R. T. McGregor, D. B. Munroe.

The resultant of the two forces = 110 lbs., in a vertical direction, and from the data given they must make an angle of 90° with each other.

Larger force = 110 cos 30° = $110\times0.8660=95.26$ lbs.

Smaller force = 110 cos 60° = $110\times0.5000=55.00$ lbs.

The easiest way for the high school student to solve this is by construction.

265. A 1.5 horse-power gasoline engine is used to drive a force pump which pumps water from a spring to a 60-gallon tank 70 ft. higher than the spring. If the tank is filled in 2 minutes, what is the efficiency of the pump? (A gallon of water weighs 8.4 lbs.)

Solution by J. P. Drake, Emporia, Kan.

Also solved by R. W. Boreman, R. T. McGregor, D. B. Munroe, Alfred Page, and Elvira Weeks.

$8.4\times60\times70=35280$ ft. lbs. in 2 min. or 17,640 ft. lbs. 1.5 H. P. = 4950 ft. lbs. Therefore the eff. = $\frac{17640}{49500}$ = 35.6+ per cent per min.

A COURTEOUS RETORT

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for July; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $5.00 per year, 60 cents a copy:* "Fertility in Cichorium Intybus: The Sporadic Occurrence of Self-Fertile Plants among the Progeny of Self-Sterile Plants," A. B. Stout; "Inheritance of Endosperm Color in Maize," Orland E. White; "The Influence of Light and Chlorophyll Formation on the Minimum Toxic Concentration of Magnesium Nitrate for the Squash," R. B. Harvey and R. H. True; "The Use of the Vibration Galvanometer with a Sixty-Cycle Alternating Current in the Measurement of the Conductivity of Electrolytes," Newton B. Green; "Immunochemical Studies of the Plant Proteins: Proteins of the Wheat-Seed and Other Cereals—Study IX," R. P. Wodehouse; "The Toxicity of Galactose and Mannose for Green Plants and the Antagonistic Action of Other Sugars toward These," Lewis Knudson.

American Mathematical Monthly, for June; *5548 Kenwood Ave., Chicago, $3.00 per year:* "Algebraical Developments Among the Egyptians and Babylonians," L. C. Karpinski; "Some Calculus Suggestions by a Student," Benjamin Graham; "On Setting Up a Definite Integral Without the Use of Duhamel's Theorem," E. V. Huntington.

Educational Psychology, for July; *Baltimore, Md.; $2.50 per year, 30 cents a copy:* "Reading as Reasoning: A Study of Mistakes in Paragraph Reading," Edward L. Thorndike; "Preliminary Investigation of Skimming in Reading," Guy M. Whipple and Josephine N. Curtis; "The Influence of Speed Drills Upon the Rate and Effectiveness of Silent Reading," Charles C. Peters.

Literary Digest, New York City: For June 30, "How Our Airmen Can Win the War;" "Why Latin-America Hesitates;" for July 7, "Effects of War-Time Prohibition;" "German Views of Our Army;" "The Tactics of Air-Fighting;" for July 14, "Civil War in China;" "The Drink Issue in England."

Photo-Era, for July; *Boston, Mass.; $1.50 per year, 15 cents a copy:* "Reflections and Shadows," William S. Davis; "Courtesy and Tact as an Asset in Press-Photography," Craig McKay; "The Photography of Wild Animals in Captivity," D. Seth-Smith; "Sky and Clouds in Photographic Views," Dr. A. Miethe; "The Tone-Rendering Capacity of Papers of the Gaslight Group," James Thomson; "The Future of Photo-Surveying from the Air."

Physical Review, for July; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "Instability of Electrified Liquid Surfaces," John Zeleny; "The Magnetization of Iron, Nickel, and Cobalt by Rotation and the Nature of the Magnetic Molecule," S. J. Barnett; "The Thermophone as a Precision Source of Sound," H. D. Arnold and I. B. Crandall; "A Condenser Transmitter as a Uniformly Sensitive Instrument for the Absolute Measurement of Sound Intensity," E. C. Wente; "The Relation of Osmotic Pressure to Temperature—II," William Francis Magie; "Proceedings of the American Physical Society."

Popular Astronomy, for June-July; *Northfield, Minn.; $4.00 per year:* "The Markings of Mars," (with Plate XIV), Alfred Rordame; "The South Polar Eclipse of 1917, December 13," William F. Rigge; "The Cordoba Durchmusterung," R. H. Tucker; "Twentieth Meeting of the American Astronomical Society" (Concluded); "The Infrequency of Connection between Solar Prominences and Spots and Faculae," Oliver J. Lee; "Photographic Magnitudes of Stars in the Selected Areas of Kapteyn," Frederick H. Seares.

Popular Science Monthly, for August; *New York City; $2.50 per year, 15 cents a copy:* "Handling a Submarine;" "The Time Fuse and How It Works;" "The Misunderstood Shark;" "America's Biggest Flying Machine;" "Putting Alcohol to Work on the Farm;" "Death Traps on German Lines;" "What's on the Moon?"

Review of Reviews, for July; *New York City; $3.00 per year, 25 cents a copy:* "War Profits to Pay for the War;" "Making Officers for

Our New Army;" "American Shipbuilding—A Real Renaissance;" "The Vitalization of City Schools."

School World, for July; *Macmillan & Company, London, Eng.; 7s 6d per year:* "Secondary School-Teachers' Salaries;" "The Departmental Committee on Salaries for Teachers in Elementary Schools;" "The Secondary-School Examinations Council."

THE WHOLE WORLD "SEEING AMERICA" ON THE SCREEN.

The vogue of the motion picture in its spread to the far quarters of the globe has been more than a simple means of amusement. It has brought into closer contact the races of differing language, those of climes which have no elements in common, and the peoples of widely divergent social customs. By means of the films, those countries which have been active in their production are already familiar places and the steady gains that have been made by the United States during the past five years toward the leadership in this industry have literally made it possible for the whole world to "see America" on a large scale while sitting in their own home towns.

In the early days of the movies American audiences grew enthusiastic over the French products that were sent across the Atlantic to reveal the wonders of this new art of the camera. Reports received from abroad furnish the information that Europe, Asia, and Africa are now showing equal enthusiasm over the perfected American films. In a single month in Paris, out of 13,800 meters of film shown 11,000 were American. A recent report from a Continental country received by the Bureau of Foreign and Domestic Commerce stated that even among the pictures that were of European origin many were reproductions of American subjects. From far-off Australia the Bureau hears that "films from well-known American companies are in general use." A consular report from South Africa states that "interest in American family and political life has been marked."

According to the official statistical volume called "Commerce and Navigation," published by the Bureau, the exports of exposed films from manufacturers in the United States increased from 32,192,018 feet, in the fiscal year 1913, to 158,751,786 feet in the fiscal year 1916.

In the last few months about one hundred reports have been received from American consular officers in all parts of the world on motion-picture markets. These, with their stories of the amusement realms of all the other nations, are not lacking in tribute to the excellence of the products of the studios of the United States. Credit has been given for the quality attained to the natural conditions that have favored the sites of various American studios. American humor is winning marked appreciation, and, most important of all, the world has learned something about America and wants to learn more.

Official figures reveal the fact that the producers of this country have been gradually turning the import trade in films from the "manufactured class" to the "raw material." Notwithstanding the immense growth in the scope of such entertainments in the United States, imports of the finished product have been dwindling for several years, and on the other hand our imports of sensitized but not exposed films have shown substantial increase in quantities. Imports of such raw material amounted to 44,717,323 feet, valued at $889,560, in 1914, and to 58,490,768 feet, valued at $750,023, in 1916. The reduction in total value gives this class of goods a unique distinction in an era of high prices.—*Department of Commerce.*

A CHEMISTRY EXPERIMENT—SUPPLEMENTARY READING.

By Agnus Bandel,
Towson High School, Towson, Md.

Problem: What outside reading may be accomplished by an elementary chemistry class in a county high school, in a town without a public library?

Materials: One teacher with a weekly schedule of twenty-five periods; one third-year class of eleven girls and eighteen boys, for five sixty-minute periods per week; one *Chemistry of Common Things*, published by Allyn and Bacon; one *Chemistry, and Its Relation to Daily Life*, Kalenberg & Hart, published by Macmillan; one *Household Chemistry*, Snell, published by Macmillan; one *Godfrey's Elementary Chemistry*, published by Longmans; one *Industrial Chemistry*, Benson, published by Macmillan; an old edition of *Encyclopedia Brittanica;* advertising material from manufacturers; the *Popular Science Monthly;* the *Literary Digest* and newspapers.

Procedure: During the first term no outside reading was required. The students were busy learning the vocabulary of science and becoming familiar with a new method of acquiring information.

During the second term each student read Faraday's *Chemical History of a Candle*, and wrote a two-paragraph theme answering the following questions: Were the lectures interesting to you? Do you think they could be readily understood by a beginner in science?

At the beginning of the third term the class was told that one long paper would be required from each pupil, but that each might make his own selection from a given list. The topics offered, the material for which was already in my possession or could easily be found, were merely suggestions. Some other topic could be substituted if the student wished. A list of about forty topics was placed in the classroom, and each student signed his name after his selection. Then all material, in the form of pamphlets or clippings from magazines and newspapers, was distributed to those needing it. Others of the class were individually told where they could obtain suitable information.

General directions for preparing the papers were given in one class period. Each student was made to feel a sense of responsibility toward the others, since the only information the class would receive on his topic would be what was included in his paper. When a book contained material needed for several papers, the students were asked to take notes from it and return it promptly. They were also advised to decide upon four or five subtopics before trying to arrange their material. The amount of time spent and the length of the paper depended entirely upon the student's interest in the subject. The papers were seldom less than ten or twelve pages, though some were much longer.

My task was to supply the material or direct the student as to where to find it, and also, if necessary, to help him in planning his paper. His task was to select material that would be most interesting to his companions and to arrange it in good paragraph form. All individual assistance was given outside of the class period.

Unless the papers applied particularly to some later lesson they were used as soon as finished. Each one was read to the class by the writer, who acted as chairman for the time. The readings were followed by a short discussion, but no notes were required from the class, for such requirement would have spoiled much of the enjoyment of the papers.

Results: The following papers were read during the term:—

"Making of Lead Pencils"; "Manufacture of Paper"; "Carborundum"; "Corn Products"—material needed for those of this group was taken

entirely from advertising circulars obtained free from manufacturers.

"Patent Medicines"; "Food Adulterations"—material needed for this group obtained chiefly from pamphlets costing from five to twenty cents.

"Modern Explosives"; "Rubber"; "Commercial Uses of Compressed Air"—material for these taken largely from magazine and newspaper articles.

"Commercial Uses of Oxygen"; "Manufacture of Soap"; "Mining of Sulphur"; "Manufacture of Glass"; "Gunpowder"; "Manufacture of Cement"; "Cotton and Linen"; "Story of Oil"; "Dyes and Dyeing"; "Story of Sugar"; "Uses of Sulphuric Acid"; "Manufacture of Washing Soda"; "Photography"; "Manufacture of Ink"; "The Electric Furnace"; "Manufacture of Matches"; "Silk and Wool"; "Story of Alcohol"; "Paints, Oils and Varnishes"; "Commercial Fertilizers"—material for topics in this last group was from the textbooks already mentioned and encyclopedias.

The other subjects offered but not chosen were:

"Commercial Uses of Hydrogen"; "Commercial Uses of Ammonia"; "Fixation of Nitrogen from the Air"; "Uses of Hydrochloric Acid"; "Headache Preparations"; "Uses of Lime"; "Commercial Uses of Carbon Dioxide"; "Refrigeration"; "Bleaching"; "Uses of Nitric Acid"; and "Fuels."

By this experiment I have found that under the conditions mentioned in the problem, considerable reading, covering a wide range of subject matter, can be accomplished without requiring too much outside time on the part of students or instructor.

Last year, after using a similar plan with a class of nineteen, the following questions were asked in the final examination in chemistry: Do you feel that the information you personally received while working on your paper was worth the time spent on it? Do you feel that the time required in class for the reading of the papers could have been used to better advantage? The class was unanimous in their approval of the outside reading.

Such work seems to me to give the students a method of gaining new knowledge for themselves by reading. The earlier part of the course teaches them to acquire facts at first hand, or directly from things. Since such a method of gaining information is necessarily slow, this later work shows them how to increase the little knowledge gained from their own experience by gathering together the experiences of others as expressed in books. It also brings to the class more material than could be acquired from one textbook, and gives the students the benefit of many different viewpoints and not those of only one teacher and one textbook writer. It keeps up with changes in industrial processes and new discoveries in science. The greatest good, however, to be derived from such supplementary reading is that, by the end of the year, the students do not feel that they "have finished chemistry," but they begin to realize they have obtained merely an introduction to a vast new field.

HUGE PHOSPHATE RESERVES.

Idaho, Utah, Wyoming, and Montana possess vast deposits of high-grade phosphate rock. Although the phosphate areas are by no means completely surveyed, the amount of phosphate in the known deposits, as estimated by the United States Geological Survey, Department of the Interior, is nearly five and one-half billion tons.

An idea of the immensity of this tonnage may be obtained by comparing it with last year's production in the United States of 1,980,000 tons.

CUTTING DOWN CHEMICAL LABORATORY EXPENSES IN HIGH SCHOOLS.

By Norman B. Adkison
Chemistry Department, Idaho Technical Institute, Pocatello, Idaho.

1. Use sodium salts in place of potassium salts whenever possible.
2. Use commercial chemicals instead of C. P. chemicals in most cases.
3. When manganese dioxide is needed as catalytic agent, I have found that this may be secured from used dry cells which contain a great deal of this very valuable compound. The powder in this form may also contain chlorides of ammonia and zinc. These will not interfere in preparing chlorine gas, but rather will aid. In preparation of oxygen if pure gas is required by the use of manganese dioxide the contents of the dry cell may be heated in advance to drive off most of its impurities.
4. Zinc is another element which has advanced in price recently, and there is no reason to believe in a fall of prices for some time to come. Zinc for ordinary use should be bought as spelter or in slabs. This can be granulated by the instructor by heating it to a molten condition and allowing it to drop slowly into a deep receptacle filled with water. This will save fifty per cent on the cost of zinc. Sufficient zinc may be obtained for small classes by taking the zinc which surrounds dry cells, melting it, and granulating in the same way. (For the Marsh test a small amount of pure zinc should be purchased.)
5. In the study of nitric oxide and nitrogen peroxide, iron may be used in place of the more expensive copper.
6. To illustrate substitution, an iron nail may be used in a blue vitriol solution instead of the expensive mercury in the costly silver nitrate solution.
7. The use of potassium permanganate should be limited, and eliminated entirely if possible, as it contains two very expensive elements—potassium and manganese.

In the suggestion to use the manganese dioxide from dry cells for catalysis, we feel that this is an important pioneer step which will enable us to utilize a waste product to take the place of a very expensive chemical.

The Chemistry Department of the Idaho Technical Institute stands ready at any time to give its expert advice or assistance in the problems of fitting or equipping the laboratory, as well as in ordering the supplies of any high school.

REPORT OF THE TWENTY-FOURTH MEETING OF THE NEW JERSEY SCIENCE TEACHERS' ASSOCIATION.

This meeting was held at the Normal School, Montclair, Saturday, May 26. The program was exceptionally interesting. Dr. Chapin, principal of the school, made the address of welcome. The first paper was by Dr. Jean Broadhurst of Columbia University on "Bacteria Work in High School," with special reference to "Teacher Preparation." This was followed by a paper on the same general thought, "Practical Pupil Work," by Henry R. Hubbard of the Plainfield High School. Fred H. Hodgson of the Montclair High School followed with his paper on "Project Teaching in Practical Botany." A general discussion of the paper by members then took place, proving very helpful to all present. At this point adjournment was made for luncheon, which was served at Edward Russ Hall.

Business first engaged the attention of the meeting at the afternoon session. Reports were received from the Secretary-Treasurer and from various committees. The Secretary was directed to secure as far as possi-

ble the publication of the following resolutions adopted at the meeting held at Atlantic City, February 10, 1917:

Resolution No. 1. "The New Jersey Science Teachers' Association recommends that the Laboratory Report in Physics and Chemistry be made on a printed or mimeographed form, which shall contain instructions and spaces for entering data, calculations, diagrams (where important), graphs (where important), and answers to a few pointed questions on each experiment."

Resolution No. 2. "The New Jersey Science Teachers' Association condemns the present custom of those colleges which mix students who have had a year or more of physics or chemistry in the same class with students who have not had these subjects. That such custom is not in reality accepting the preparatory work of the entering student. Futhermore it kills the interest of the student, and brings unjust criticism on the instructor in the secondary school."

The topic for consideration at the afternoon session was, "Teaching Through Projects," by Dr. David S. Snedden of Teachers College, Columbia University. The paper was discussed by Dr. C. H. Robinson, Normal School, Montclair; Dr. D. R. Hodgdon, Normal School, Newark; Dr. George W. Hunter, De Witt Clinton High School, New York City; and Merton C. Leonard, Dickinson High School, Jersey City. General discussion by members also took place. The summary of the sessions was given by Mr. J. A. Randall of the Pratt Institute.

The officer elected for the ensuing year are as follows:

President—Earl Eastman, High School, Atlantic City.

Vice-President—M. C. Leonard, Dickinson High School, Jersey City.

Secretary-Treasurer—R. S. Blodgett, High School, Caldwell.

Executive Committee—H. Morgan Campbell, High School, Bayonne; Melville T. Cook, Rutgers College, New Brunswick; Miss Agnes Vinton Luthers, Normal School, Newark.

Section Chairmen—Agriculture, Biology, Dr. C. H. Robinson, Normal School, Montclair; Elementary Science, Miss Caroline G. Howe, South Side High School, Newark; Physics, E. R. Vactor, High School, West Hoboken.

PLATINUM IN 1916.

Preliminary estimates based on practically complete returns made to the United States Geological Survey, Department of the Interior, by domestic refiners of platinum indicate that in 1916 approximately 488 ounces of domestic crude platinum (about seventy-four per cent metal) were refined, producing 172 ounces platinum, 84 ounces of iridium, and 113 ounces of iridosmine, and that 10,118 ounces of South American crude platinum, about eighty-eight per cent pure, were refined.

The platinum metals produced by refining crude placer platinum, of both foreign and domestic origin, amounted to 8,943 ounces platinum, 235 ounces iridium, 199 ounces iridosmine, and 18 ounces palladium.

Refiners of copper matte and gold bullion report a production from foreign and domestic material of 2,556 ounces platinum, 100 ounces iridium, and 2,746 ounces palladium. About half of this output was produced from domestic materials.

The total production of new platinum metals in 1916 was about 11,500 ounces of platinum, 335 ounces iridium, 200 ounces iridosmine, and 2,765 ounces palladium.

The scrap platinum metals sold in the United States in 1916 amounted to approximately 49,400 ounces of platinum, 980 ounces iridium, and 2,000 ounces palladium.

BIBLIOGRAPHY OF AMERICAN GEOLOGY.

The United States Geological Survey, Department of the Interior, has issued as Bulletin 645 its "Bibliography of North American Geology for 1915," by J. M. Nickles. This bulletin is a list of the books, papers, and maps bearing on the geology (including the paleontology, petrology, and mineralogy) of North America and adjacent islands, and of Panama and Hawaii, issued in 1915. The papers are arranged alphabetically by names of authors and the bulletin contains a full alphabetical subject index by which any paper relating to any particular subject or area may be readily found.

This bibliography is one of a series, the volume for 1911 forming Bulletin 524, that for 1912 Bulletin 545, that for 1913 Bulletin 584, and that for 1914 Bulletin 617. From time to time these bibliographies are combined in a single volume covering several years. The series now covers the literature of American geology from 1732 to the end of 1915. Bulletin 645 may be obtained on application to the Director of the United States Geological Survey, Washington, D. C.

BOOKS RECEIVED.

Sixth Biennial Report of the State Superintendent of Public Instruction of Oklahoma. 252 pages. 16x23.5 cm. Cloth. 1916. R. H. Wilson, State Superintendent.

A First Course in Higher Algebra, by Helen A. Merrill and Clara E. Smith, Wellesley College. Pages xiv+247. 13x19.5 cm Cloth. 1917. $1.50. The Macmillan Company, New York City.

Finite Collineation Groups, by H. F. Blichfeldt, Leland Stanford Junior University. Pages xi+193. 13x19.5 cm. Cloth. 1917. $1.50 The University of Chicago Press, Chicago.

The New Barnes Problem Books, Seventh and Eighth Years, First and Second Halves, by Abraham Smith, Public Schools, New York City. 70 pages each. 12.5x19 cm. Paper. 1917. 10 cents each. A. S. Barnes Company, New York City.

Vocational Mathematics for Girls, by William H. Dooley. Pages vi+369. 13.5x19 cm. Cloth. 1917. D. C. Heath & Company, Boston, Mass.

The Home and Its Management, by Mabel Hyde Kittredge, New York City. 385 pages. 13.5x19.5 cm. Cloth. 1917. $1.50. The Century Company, New York City.

Laws of Physical Science, by Edwin F. Northrup, Princeton University. Pages ix+210. 13.5x20 cm. Limp leather. 1917. $2.00 net. J. B. Lippincott Company, Philadelphia.

First Course in Algebra, by Herbert E. Hawkes, Columbia University, William A. Luby, Kansas City Polytechnic Institute, and Frank C. Touton. Pages ix+301. 13x19 cm. Cloth. 1917. $1.00. Ginn & Company, Boston.

Vocational Mathematics, by William H. Dooley, Technical High School, Fall River, Mass. Pages viii+341. 13.5x19 cm. Cloth. 1917 D. C. Heath & Company, Boston.

Experiments in Educational Psychology, by Daniel Starch, University of Wisconsin. Pages ix+204. 13.5x19.5 cm. Cloth. 1917. $1.00, The Macmillan Company, New York City.

The Basis of Durable Peace, by Cosmos, for the New York Times. Pages ix+144. 13.5x20 cm. Charles Scribners Sons, New York City.

Essentials in Mechanical Drawing, by L. J. Smith, Manitoba Agricultural College. Pages vi+57. 13x19.5 cm. Cloth. 1917. 50c. The Macmillan Company, New York City.

A Manual of Mathematics, by Ralph G. Hudson and Joseph Lipka, Massachusetts Institute of Technology. Pages iii+132. 13x20.5 cm. Paper. 1917. John Wiley & Son, New York City.

A Table of Integrals as above. 25 pages. 13x20 cm. Paper. 1917.

Laboratory Manual for Introduction to Science, by Bertha M. Clark, William Penn High School for Girls, Philadelphia. 203 pages. 19.5x24.5 cm. Loose leaf. Paper. 1917. American Book Company, Chicago.

The Life of Inland Waters, by James G. Needham and J. T. Lloyd of Cornell University. 438 pages. 16.5x23.5 cm. Cloth. 1916. $3.00. Comstock Publishing Company, Utica, New York.

How to Know the Mosses—A Popular Guide to the Mosses of the Northeastern United States, by Elizabeth M. Dunham, Member of the Sullivant Moss Society. Pages xxi+287. 13x19 cm. 1916. $1.25 net. Houghton, Mifflin Company, Boston, Mass.

General Science—First Course, by Lewis Elhuff, George Westinghouse High School, Pittsburgh, Pa. Pages viii+433. 13.5x19 cm. Cloth. 1916. D. C. Heath & Company, Boston.

BOOK REVIEWS.

Preliminary Mathematics, by F. E. Austin, E. E., Hanover, N. H. Pages 169. 13x19 cm. $1.20. 1917. Published by the author.

To help young pupils to understand the symbolism and processes of algebra by a close connection with arithmetic, to show practical applications of the theories discussed, and to show how to solve problems, are the aims of this book. Part I is written especially for pupils of the eighth grade, and Part II for high school pupils. The book is to be used in connection with a standard textbook in algebra. The first seventy-seven pages, Part I, deal largely with the numerical value of algebraic expressions, and the use of the table of logarithms is explained. In the remaining pages ninety-six problems are given with their solutions, and some unsolved problems, including square root, quadratic equations, ratio and proportion, and arithmetic and geometric series. The closing pages include tables and college entrance examinations. H. E. C.

First Course in Algebra, Revised Edition, by Herbert E. Hawkes, Professor of Mathematics in Columbia University, William A. Luby, Head of the Department of Mathematics, Kansas City Polytechnic Institute, and Frank C. Touton, formerly Principal of the Central High School, St. Joseph, Mo. Pages ix+301. 13x19 cm. $1.00. 1917. Ginn & Company, Boston.

The large number of teachers who have been using the former edition will be interested in this book, since with no loss of thoroughness in treatment and little change in scope the subject is presented in a form more easily grasped by first-year pupils. The lists of problems and exercises are for the most part new and contain a greater proportion of easy exercises with simple results. The inclusion of many simple oral exercises to introduce and illustrate each new idea or operation will be appreciated by both teachers and pupils. The definitions and axioms are expressed in the simplest language which is consistent with accuracy, and the development of the problem work is of a nature to serve as an efficient aid in this most important and difficult part of algebra. In all respects this revision reflects the high standard of the authors and publishers.

H. E. C.

The Theory of Measurements, by Lucius Tuttle, M. D., Associate in Physics, Jefferson Medical College, Philadelphia. Pages xiv+303. 14x21 cm. $1.25. 1916. Jefferson Laboratory of Physics, Philadelphia.

Teachers of secondary school mathematics will find this a most valuable reference book. The new standard textbooks in algebra and geometry are including considerable work of a practical nature, graphs, approximate number, computation, and so on, which cannot be of the greatest use to pupils unless the teacher has a fairly good knowledge of the facts and methods involved. The low price of this book, the clear, simple, detailed explanations, and wide range of application make it easily the first choice of a reference book. The teacher of high school mathematics who reads this book understandingly will never be found opposing "graphs" and "practical mathematics."

This course in the theory of measurements is for the most part laid out in laboratory exercises as a preliminary to laboratory work or practical work in such subjects as astronomy, physics, psychology, or surveying. For this purpose it is a real textbook and emphasizes the accurate exercise of the reasoning powers of the student. The titles of some of the chapters are: "Weights and Measures;" "Significant Figures;" "Small Magnitudes;" "The Slide Rule;" "Graphic Representation;" "Graphic Analysis;" "Accuracy;" "The Principle of Coincidence;" "Measurement and Errors;" "Statistical Methods;" "Deviation and Dispersion;" "Least Squares;" "Indirect Measurement;" "Systematic and Constant Errors." The appendix contains a number of tables. H. E. C.

Arithmetic Aids. Instruction and Drill Book. Pages 102. 15x22 cm. Paper covers. The Practical Textbook Company.

This book is devoted wholly to practical contractions which are given not merely as arbitrary formulas to be followed blindly. Either the principle is deduced or the pupil is led to develop it for himself, and the formula for the abridged method follows as a natural consequence. Most of the computations of the usual course in arithmetic are covered by the problems and exercises. With this book is to be used the *Speed Exercises in Practical Arithmetic*, containing one hundred speed exercises. Each exercise is to be worked by the watch, in blank spaces indicated, the sheet to be signed, torn off, and handed to the teacher.

H. E. C.

Essentials in Mechanical Drawing, by L. J. Smith, Manitoba Agricultural College. Pages vi+57. 13x19.25 cm. Cloth. 1917. 50 cents. The Macmillan Company, New York City.

A splendid title book, giving the essentials of mechanical drawing as it occurs in daily life. Just the book to put into the hands of the beginner in this subject. Small drawing boards may be used with this text. There are thirty-five well executed illustrative drawings. C. H. S.

Science and Learning in France, with a Survey of Opportunities for American Students in French Universities. An Appreciation by American Scholars. Pages xxxviii+454. 1917. The Society for American Fellowships in French Universities. Cloth, $1.50. Paper, $1.00. McClurg & Co., Chicago.

This volume aims to be especially useful to the student who expects to spend some time in France in graduate study, but it is also well adapted for the use of those who would like to acquire a correct

notion in regard to the scientific contributions made by the French nation. The different parts were written by specialists of high standing. Most of these parts cover separately only half a dozen pages, and hence they are confined to the most interesting and fundamental facts relating to the subjects under consideration.

The Introduction is divided into two parts, entitled, respectively, "The Mind of France" and "The Intellectual Inspiration of Paris." These parts were prepared by C. W. Eliot, President Emeritus of Harvard University, and G. E. Hale, Foreign Secretary of the National Academy of Sciences, Correspondent of the Institute of France. The main body of the volume is divided into twenty-six parts, with various subdivisions, and contains a clear exposition of the advantages for study at various French institutions of learning.

Appendix I, pages 347–371, is entitled "Educational Advantages for American Students in France; with a History of Recent Changes in its University System." Appendix II, pages 375–412, is headed "Institutions of Higher Learning; Their Organization, Degrees, Requirements, Fees, etc." Appendix III, pages 415–426, bears the heading "Practical Suggestions to the Intending Graduate Student." The first of these articles was prepared by Professor James Geddes, Jr., of Boston University, while the other two are from the pen of Professor C. B. Vibbert, of the University of Michigan.

As may be inferred from the title, the volume is intended to represent a national movement, and this feature is emphasized by a list of about one thousand "sponsors," including many of the leading American educators and investigators. A more impressive gift from the scholars of one nation to those of another has perhaps never been made, and our entrance into the great war as an ally of France after the present volume was far advanced increases the impressiveness of this token of appreciation. G. A. Miller.

A Manual of Mathematics, by Ralph G. Hudson and Joseph Lipka, Massachusetts Institute of Technology. Pages iii+132. 13x20 cm. Cloth. 1917. Also a *Table of Integrals* by same authors. 25 pages. 13x20 cm. Paper. 1917. John Wiley & Sons, New York City.

This is a splendid collection of mathematical formulas and tables which has been compiled for classroom use and for work in general. The expressions are those which are generally used by students of mathematics and engineering. They are conveniently arranged and can quickly be found. The book contains formulas under the heads of algebra, trigonometry, mensuration, analytic geometry, differential and integral calculus, differential equations, complex quantities, vectors and hyperbolic functions. There are tables of mathematical symbols and abbreviations, common and natural logarithms, squares, cubes, square roots, cube roots, reciprocals, circumferences and circular areas of numbers from 1 to 1,000, degrees of radians, natural sines, cosines and tangents, common logarithms of sines, cosines and tangents, hyperbolic sines, cosines and tangents, values of ϵ^{-x} and ϵ^{-x}, decimal equivalents of fractions, and conversion factors for practically all units. It is a valuable book for all mathematicians and engineers. C. H. S.

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Under this heading are published in the March, June, and October issues of this journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. Names are dropped when they become a year old.

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